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Investigating the human—environment relationship of early intensive salt production: A case study from the Upper Seille Valley, Lorraine, northeast France

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Abstract

This paper presents the latest findings of multi-disciplinary research into the human—environment relationship of intensive Iron Age salt production in the Upper Seille Valley, Lorraine, northeast France. Investigations focus on the early Iron Age workshop "La Digue" (~625—500 cal BCE; Hallstatt D1—2), where high-resolution borehole sampling has been coupled with conventional excavation and geophysical surveying to establish direct linkages between intensive occupation and the alluvial environment of this site. Detailed insights into human—river interactions have been identified, enhancing current understanding of the environmental context and impact of this important early industry. The workshop's palaeogeographic setting has been reconstructed and new evidence for briquetage disposal practices has been identified, confirming that a close relationship existed between salt-making and the local hydrological regime. A large volume of briquetage waste (broken clay-fired salt-making equipment, ash and charcoal) was dumped into the river at La Digue, causing rapid and deliberate channel blockage, increasing the distance between the workshop and the river. This probably contributed to a localised increase in channel mobility and/or flooding whilst the workshop was active, producing challenging conditions for salt production. The workshop was abandoned following an intense flood event in ~ 500 cal BCE, coinciding with a major hydrological shift towards wetter floodplain conditions, likely arising from a combination of natural and anthropogenic factors. This study demonstrates the importance of understanding the environmental context of salt production and the roles of water management and briquetage disposal practices, which have been largely overlooked at other intensive salt making sites that employed the "briquetage technique".

Keywords
Alluvial environment; Briquetage; Palaeogeography; Palaeohydrology; Salt production; Upper Seille Valley

1. Introduction

Salt was an important commodity during later prehistory, and is considered to have brought great power and wealth to those controlling its production and trade (Alexander, 1982; Fawn *et al.*, 1990; Flad *et al.*, 2005; Shotter, 2005). It was, for example, one of the earliest known commodities to be taxed (Tora and Vogel, 1993) and it generated considerable revenue for the Roman Empire: Cities such as Rome flourished due to strategic positions on salt trading routes (Shotter, 2005). There was an enormous increase in the scale of production from the late Bronze Age—early Iron Age onwards, with the emergence of a large number of intensive salt making centres across northwest Europe (Fawn *et al.*, 1990; Harding, 2013; Olivier and Kovacik, 2006) (Figure 1). This has raised important questions about its social and economic implications and the technology involved, which research over the past forty years has begun to address (*e.g.*, Alexander, 1982; Alexianu *et al.*, 2011; Arrowsmith and Power, 2012; de Brissay and Evans, 1975; Fawn *et al.*, 1990; Fielding and Fielding, 2005; Flad *et al.*, 2009; Harding, 2013; Kinory, 2012; Langouët *et al.*, 1994; Nevell and Fielding, 2005).

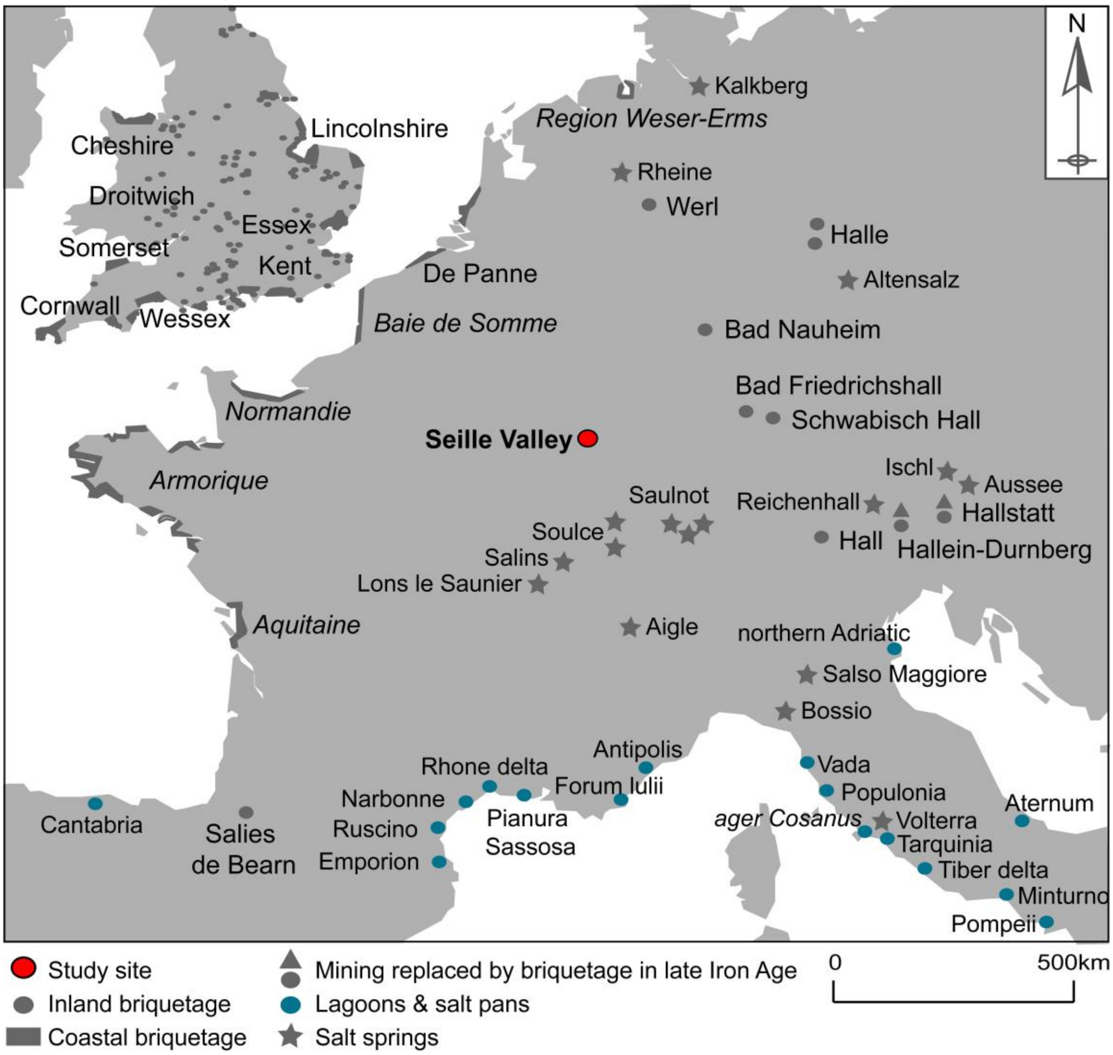

Figure 1: Map of Late Bronze Age, Iron Age and Roman salt-making sites in northwest Europe. Salt was mainly harvested using forced evaporation in furnaces (the "briquetage technique") in northern temperate localities, whilst solar evaporation in lagoons and salt pans was commonly practiced in the Mediterranean region. Redrawn from Harding (2013), Kinory (2012) and Olivier and Kovacik (2006).

This paper focuses on harvesting of salt using the "briquetage technique", involving forced evaporation of saline solutions (derived from brine springs, sea water or salt-rich sediments) in furnaces: This was the primary method employed during later prehistory (Biddulph *et al.*, 2012; Harding, 2013). Despite the intrinsic link between salt and the environment, which must have played a key role in the establishment, success and longevity of production at these sites, consideration of the environmental context and impact of salt-making is conspicuously absent in an everexpanding literature, with few exceptions (*e.g.*, Biddulph *et al*., 2012; Dufraisse and Gauthier, 2002; Grossi *et al.*, 2015; Lane, 2005; Lane and Morris, 2001; Nevell, 2005; Woodiwiss, 1992; ZhiBin, 2008). At best, palaeoenvironmental investigations are typically limited to charcoal and faunal remains recovered during excavation, with virtually no systematic landscape survey coupled with detailed analyses and reconstruction of the environmental history of the immediate and wider area, such as that recommended by Howard *et al.* (2014). This inevitably limits understanding of site organisation, production activities, environmental impacts, and the implications of natural and/or anthropogenically-induced environmental change for the development and resilience of these intensive production centres.

The overarching aims of the Briquetage de la Seille project are to reconstruct and elucidate the relationship between intensive salt production activities and changes in the natural environment during later prehistory, and to formulate a methodological framework within which to investigate these issues. Research has encompassed long-term Holocene palaeoenvironmental and palaeohydrological change and human occupation of the Upper Seille Valley to establish a baseline against which any environmental changes at the time of, and/or following, establishment of the industry could be assessed and probable causal factors determined (Jusseret *et al.*, 2015; Riddiford *et al.*, 2012). These landscape-scale investigations (described in Riddiford *et al.*, 2012) suggest the industry had a major impact on the area's sedimentological history and hydrological regime. However, the broad spatial and temporal resolution of this initial work limited the extent to which the precise human—environment relationship of salt production could be established. The present research aims to address this issue through the integration of intensive borehole surveying and excavation at a single site, the early Iron Age workshop of "La Digue" (Figures 2 and 3). This approach allows direct linkages to be established between the intense, chronologically confined, occupation of La Digue (covering approximately 125 years, from ~625—500 cal BC, i.e. Hallstatt D1—2) and local alluvial environments. The results reveal important new insights into workshop organisation, human—river interactions and probable hydrological impacts of early industrial salt production.

2. Upper Seille Valley: Archaeological and environmental background

Archaeological and sedimentological evidence suggest that intensive salt production in the Upper Seille Valley began ~600 cal BCE, following a shift from prolonged active river migration and widespread erosion, typical of the region (Notebaert and Verstraeten, 2010), to more stable floodplain conditions and rapid sparsely organic silt and clay accumulation (Olivier, 2010; Riddiford *et al.*, 2012): Extensive structural remains of the industry have been identified (Olivier and Kovacik, 2006, 2007) and fluvially-redeposited (sand and gravel-sized) briquetage is consistently recorded for the first time towards the base of a sparsely organic sedimentary unit, signaling that salt production had begun. Alluviation accelerated from this period onwards and the palaeoenvironmental record becomes dominated by evidence for woodland clearance, agriculture and bare/disturbed ground (Riddiford *et al.*, 2012).

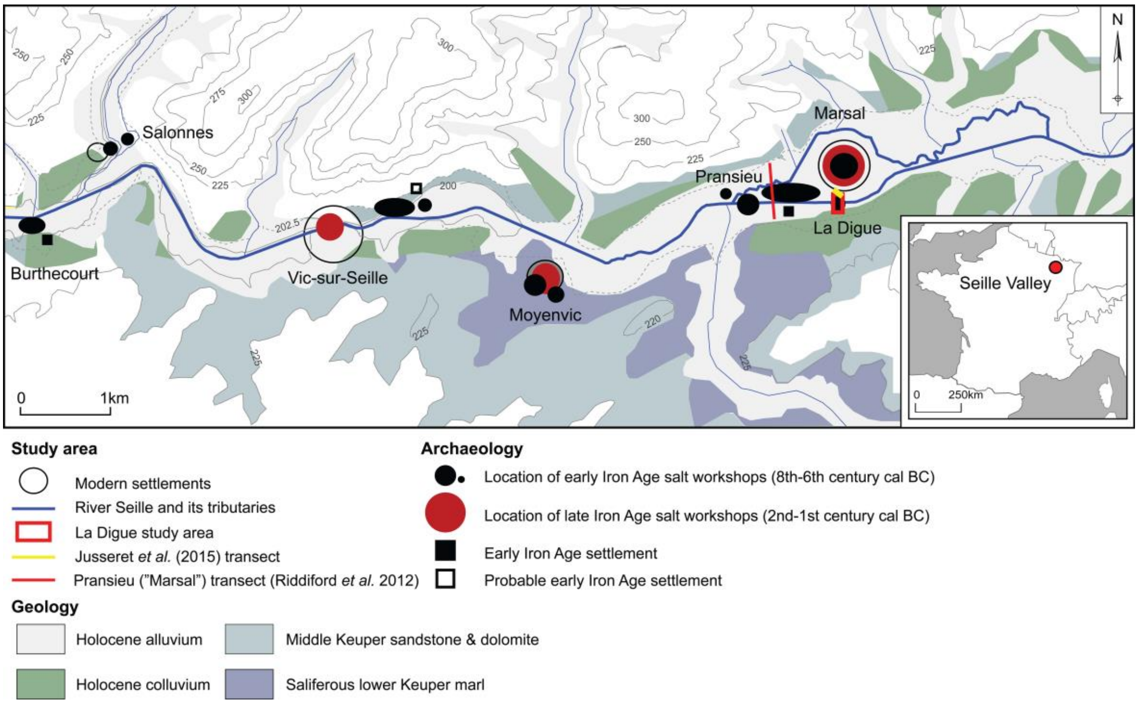

Figure 2: The Seille Valley study area showing the location of the La Digue study area and Marsal ("Pransieu") cross-valley transect discussed in Riddiford *et al.* (2012). The spatial relationship between the study area, salt archaeology and salt-bearing geology (influencing the distribution of brine springs) is shown. This schematic map is adapted from Goguel (1959), Marchal *et al.* (1972), Olivier and Kovacik (2006), Riddiford *et al.* (2012) and Jusseret *et al.* (2015).

Approximately ten workshops were established on the floodplain between the modern towns of Marsal and Salonnes during the early Iron Age (8th to 6th century cal BCE) (Figure 2). Pollen evidence suggests saltmarsh has been present in this area since at least ~6050 cal BCE (~8000 cal BP) (Riddiford *et al.*, 2012) and brine springs are still common. These are related to the local presence of saliferous lower Keuper formations at shallow depth (~50—80 m) (Baubron *et al.*, 2004), and probably also to groundwater recharge in elevated regions producing resurgences enriched in dissolved salts (Cheval *et al.*, 2004). Historical accounts and recent observations suggest that important and rapid annual and seasonal changes have occurred in the salt concentration of these springs (*cf.* Baubron *et al.*, 2004; Cheval *et al.*, 2004). Watertable height and flood frequency probably also influenced the number and concentration of brine springs over the longer-term.

A large volume of waste (primarily briquetage) totaling around 3—4 million metres^3 accumulated at salt workshops during the Iron Age, forming mounds up to 12 m thick and 500 m in diameter. At the previously studied Pransieu workshop (Figures 2 and 3) (referred to as "Marsal" in Riddiford *et al.*, 2012), blocky (*in-situ*) and sand and gravel-sized (redeposited) briquetage began accumulating on the surface of a palaeosol radiocarbon dated to 1450—1270 cal BCE (3400—3220 cal BP) (Wk-212899): OSL dating suggests this began in the mid-to-late Bronze Age (1640—1160 cal BCE; 3650—3170 cal BP (OSL date ML9)), although corroborating archaeological evidence for pre-Iron Age salt production has yet to be identified (Riddiford *et al.*, 2012). The presence of a palaeochannel to the south of the Pransieu workshop has been indirectly inferred from the sediment stratigraphy, whilst late Iron Age palaeochannel deposits (180 cal BCE—50 CE; 2130—1900 cal BP (Wk-21287)) have been identified to the north. It has been hypothesised that briquetage accumulation led to gradual channel blockage and migration, followed by channel abandonment and relocation. This is likely to have impacted on the local hydrological regime and there is pollen evidence for widespread marsh development from ~500–250 cal BCE (~2450–2200 cal BP) onwards (Riddiford *et al.*, 2012).

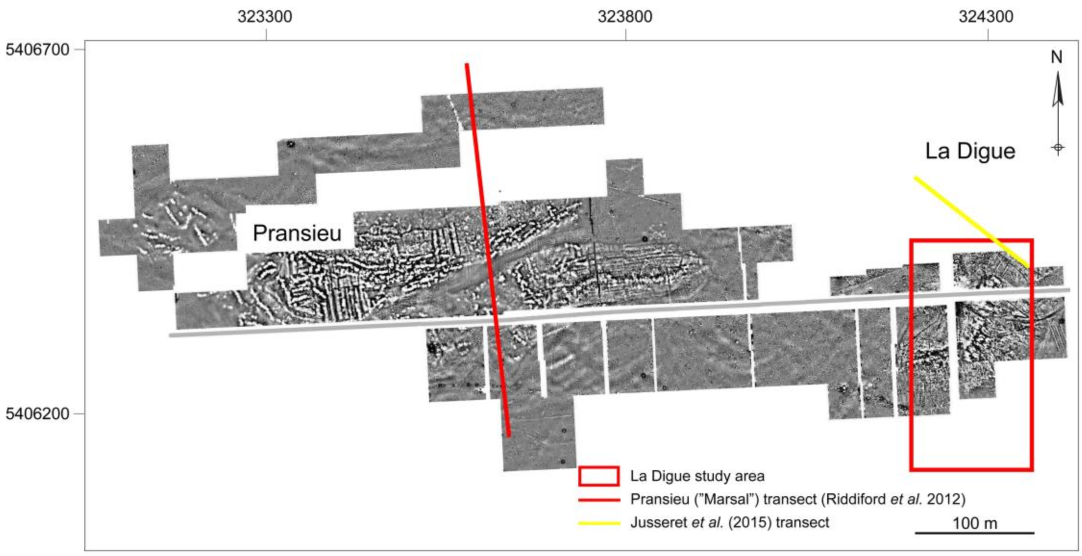

Figure 3: Geophysical survey of the Pransieu and La Digue early Iron Age Workshops, showing the position of the La Digue study area, and borehole transects undertaken at La Digue (Jusseret *et al.*, 2015) and Pransieu (Riddiford *et al.*, 2012). White/black: +/- 5 nT, UTM 32N (WGS 84) coordinate system, image courtesy of Posselt & Zickgraf Prospektionen GbR, Marbourg.

This occurred during a period of pronounced climatic deterioration, regionally-elevated groundwater and increased flood frequency (Brown, 1997; van Geel *et al.*, 1996; Notebaert and Verstraeten, 2010), which is also likely to have exerted an influence on the hydrological system.

Early Iron Age workshops in the Upper Seille Valley apparently ceased operating by the first half of the 5th century cal BCE, and there is a hiatus in the archaeological record until the second half of the 3rd century cal BCE. What happens during this period is presently unknown: Significantly, archaeological evidence for renewed salt production in the 3rd century cal BCE is characterised by new technologies (small rounded briquetage bars, narrow salt moulds), associated with growth and reorganisation of the industry (Olivier, 2010). Production peaked in the late Iron Age (2nd to 1st century cal BCE), when workshops became focused at Marsal, Moyenvic and Vic-sur-Seille (Olivier and Kovacik, 2006; Olivier, 2010) (Figure 2). The largest briquetage mounds are present at these sites and settlements were probably established on top of the mounds from the Roman period onwards. Although it is likely that the briquetage technique was abandoned at the end of the Iron Age, little is known of salt extraction in the Upper Seille Valley during the Roman period and Early Middle Ages: It is not until the twelfth century that saltworks are regularly mentioned in local historical records (Multhauf, 1978).

The present study focuses on La Digue, a 120 m x 300 m section of the floodplain immediately south of the village of Marsal (32N 324390 5406650, elevation 202 m above sea level (m a.s.l.)) (Figure 2). This is essentially a type site for Iron Age salt production in the Upper Seille Valley, having been the subject of archaeological tests in the 1970s (Bertaux, 1972a, 1972b, 1972c, 1976) and detailed investigations by the Briquetage de la Seille project from 2001—2014 (geomagnetic prospections, archaeological tests, systematic excavations) (Olivier, 2000, 2010; Olivier and Kovacik, 2006, 2007; Olivier *et al.*, 2010) (Figure 4a—h). An early Iron Age workshop dating to ~625–500 cal BCE (Hallstatt D1—2) has been identified at this locality (Olivier, 2014), evident in Figure 3 as a southwest to northeast trending zone of geomagnetic anomalies. Chronology was established using radiocarbon dating of furnace charcoal, and refined using relative dating of briquetage and domestic pottery found in association with archaeological features (Olivier, 2010). Early Iron Age pits, wood-lined storage basins, furnaces, post holes and large quantities of briquetage have been identified during excavation (Figure 4a—d) (Olivier, 2010; Olivier *et al.*, 2010). High-resolution borehole surveying was integral to the excavation strategy, making it possible to investigate the precise relationship between salt production and the floodplain environment for the first time. The objectives of the survey were to:

1. Reconstruct the palaeogeographic setting of the La Digue workshop;
2. Establish a clearer understanding of briquetage disposal practices.

The latter has been achieved by determining the spatial relationship between the workshop and the river during the early Iron Age, and assessing whether there is any direct evidence for briquetage channel blockage. The findings are presented here.

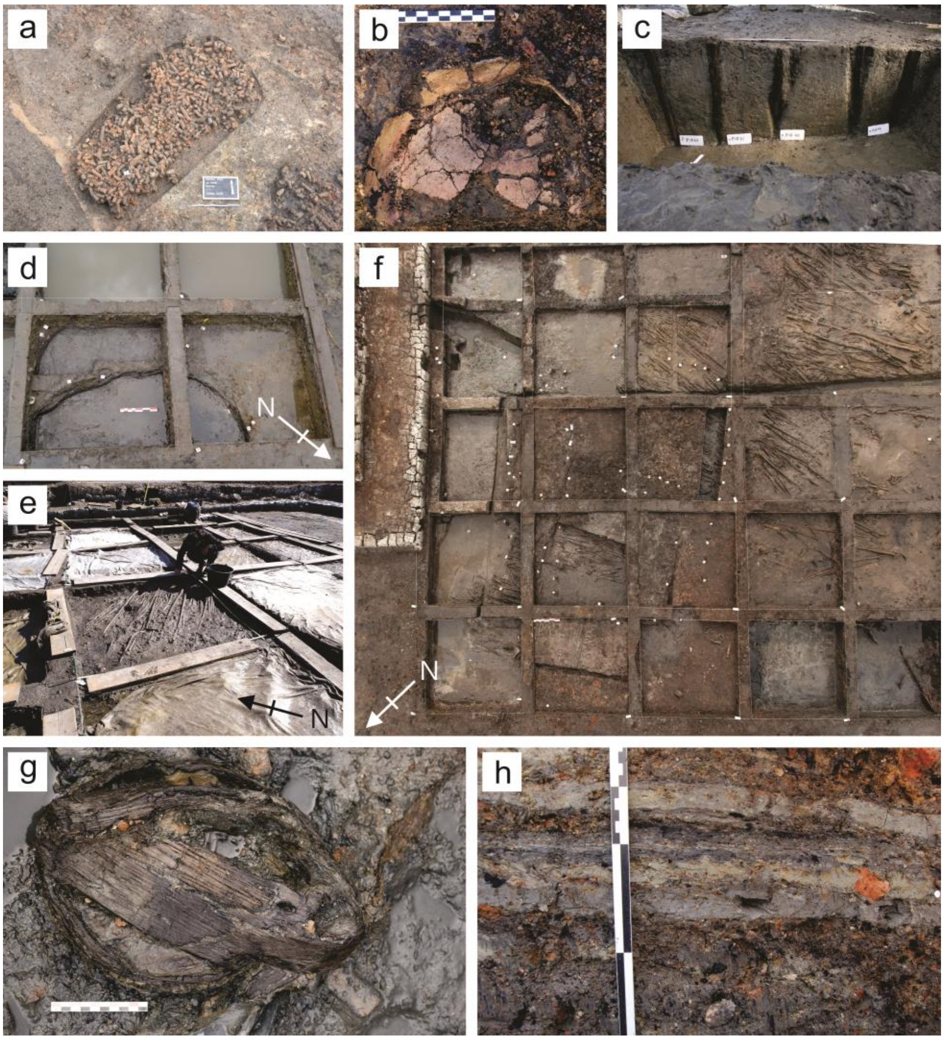

Figure 4: Marsal, La Digue: Early Iron Age (Hallstatt D1-2) remains of salt extraction activities. a: pit containing briquetage debris; b: clay salt mould *in situ*; c: wooden posts driven in grey silty clay (floodplain) deposits; d: wood-lined basin (settling tank?); e—f: wooden surface exposed at the base of briquetage deposits, resting on grey silty clay (floodplain) deposits; g: remains of wooden bucket, possibly used for brine extraction; h: typical archaeological stratigraphy at La Digue, showing alternation of briquetage deposits (black, orange) and floodplain sediments (grey).

3. Method

Forty-seven boreholes were put down in a series of transects using an Eijkelkamp percussion gouge set powered by an Atlas Copco Cobra TT 2-stroke percussion engine. This was accompanied by targeted coring (ten boreholes) to resolve the position of specific features, such as palaeochannels and briquetage distribution. Spatial attributes were recorded using a Leica Differential Global Positioning System and lithostratigraphy was described in the field using standard procedures for recording unconsolidated sediment (Jones *et al.*, 1999). Surface elevation of each core sample was determined using differential levelling, with reference to the site datum (32N 324271, 5406339; 201.91 m a.s.l.). Selected core samples were returned to the laboratory at the University of Reading for further description, analyses and radiocarbon dating. The onset of salt production is clearly evident from the widespread occurrence of fluvially redeposited sand and gravel-sized briquetage and charcoal, and blocky *in-situ* deposits. This stratigraphic marker, together with radiocarbon dating of important stratigraphic horizons, such as occupation deposits, archaeology and channel deposits, was used to reconstruct the early Iron Age floodplain topography at La Digue. Elevation data were converted to raster and inverse-distance-weighted analysis was performed to interpolate between data points using ArcScene GIS version 10.0. Eighteen AMS dates were submitted for radiocarbon dating to Beta Analytic INC, Florida, USA (Table 1). The results were calibrated using OxCal v4.2.3 (Bronk Ramsey, 2009; Bronk Ramsey and Lee, 2013) and the INTCAL13 calibration curve (Reimer *et al.*, 2013). The maximum intercept method was used to calculate date ranges and these are quoted at two-sigma (95.4%) confidence. Overall, this methodology has permitted a detailed indication of the spatial extent of salt production activities and the sedimentary and human history of this locality.

4. Results and Interpretation: Lateglacial and Holocene sediment stratigraphy at La Digue

As we are not focusing on pre-Holocene sediments in this paper, these are only mentioned briefly. A cross-section of the early Iron Age workshop and adjacent floodplain is illustrated in Figure 5, and core samples containing channel deposits are illustrated in Figure 6. The locations of all core samples collected in the study area are shown in Figure 7.

Table 1: AMS radiocarbon dates obtained from selected borehole core samples at "La Digue".

Borehole	Borehole surface elevation (m a.s.l.)	Sample elevation (m a.s.l.)	Radiocarbon date (years bp)	Calibrated age at 2 δ range (years BCE/CE)	Radiocarbon laboratory reference	$^{13}C/^{12}C$ ratio (‰)	Material dated
BH52	202.04	199.58–199.56	2920 ± 40	1260–1000 BCE	Beta-266133	-26.6	Organic sediment
BH52	202.04	199.48–199.46	3160 ± 40	1510–1300 BCE	Beta-266134	-28.0	Organic sediment
BH69-L	201.83	200.74–200.72	850 ± 30	1050–1260 CE	Beta-365359	-29.0	Organic sediment
BH69-L	201.83	199.63–199.61	2500 ± 40	790–490 BCE	Beta-285295	-27.8	Organic sediment
BH69-L	201.83	199.46–199.44	2380 ± 40	740–380 BCE	Beta-285294	-25.8	Organic sediment
BH69-L	201.83	199.18–199.16	2420 ± 40	750–400 BCE	Beta-285293	-26.6	Organic sediment
BH69-L	201.83	198.71–198.69	4770 ± 40	3640–3380 BCE	Beta-285292	Not available	Organic sediment
BH69-L	201.83	198.28–198.26	5910 ±40	4900–4710 BCE	Beta-285291	-25.8	Organic sediment
BH69-L	201.83	198.05–198.03	6720 ± 40	5720–5560 BCE	Beta-285290	-27.0	Organic sediment
BH69-L	201.83	197.77–197.74	8660 ± 50	7810–7580 BCE	Beta-285288	-34.2	Organic sediment
BH69-L	201.83	197.64–197.62	9690 ± 50	9280–8850 BCE	Beta-285287	-26.9	Organic sediment
BH69-L	201.83	197.46–197.43	9650 ± 50	9250–8840 BCE	Beta-285286	-27.2	Organic sediment
BH69-L	201.83	197.19–197.16	10,150 ± 50	10,100–9550 BCE	Beta-285285	-31.3	Organic sediment
BH81-L	201.57	199.95–199.94	2480 ± 30	770–430 BCE	Beta-310885	-26.2	Charred material
BH88-L	201.99	197.80–197.78	3950 ± 40	2570–2310 BCE	Beta-310887	-27.6	Organic sediment
BH88-L	201.99	197.39–197.35	3320 ± 30	1680–1520 BCE	Beta-310888	-28.3	Wood
BH88-L	201.99	197.15–197.13	9930 ± 50	9660–9290 BCE	Beta-310889	-30.6	Organic sediment
BH99-L	202.66	197.93–197.89	3510 ± 40	1940–1700 BCE	Beta-310890	-27.7	Organic sediment

4.1 Sand and gravel "terrace" (Pleistocene)

This unit is characterised by light to dark grey and reddish brown silty sandy gravel and sandy clay. The top of this unit is encountered between 5.13 m and 2 m below present day ground surface (196.88 m a.s.l. (BH77) to 199.8 m a.s.l (BH78)), creating a raised sub-surface feature ("terrace") in the east of the study area (Figures 5 and 6). This terrace represents a former (pre-Holocene) stage in the shaping of the valley floor by the river. Inorganic and organic sub-units (containing wood and shell fragments, Mollusca and possible roots) have frequently been identified and mottling/Iron staining is common in core samples BH78, BH80, BH81-L and BH82, implying oxidation and pedogenesis.

4.2 Palaeochannel (late Pleistocene—early Holocene)

This unit is characterised by yellow sand-rich horizons (BH104) and light to dark greyish brown or black, occasionally organic, sandy silt and silty clay (BH68; BH69-L; BH77; BH88-L; BH100; BH104; BH105) (Figures 5 and 6). It is recorded between 196.88 m (BH77) and 197.97 m a.s.l. (BH105). Mollusca and laminated *Phragmites* stem fragments are common. This has been interpreted as a palaeochannel, radiocarbon dated to between 10,100–9550 cal BCE (Beta-285285) and 7810–7580 cal BCE (Beta-285288) in BH69-L.

4.3 Alluvium (early to mid-Holocene)

This unit is characterised by initially dark greyish brown peaty silty clay followed by light and dark grey clay-rich silt in core samples BH68 and BH69-L. It is recorded between 197.51 m and 198.38 m a.s.l. in BH68 and between 197.75 m and 198.74 m a.s.l. in BH69-L (Figure 5). Small fragments of unidentified woody remains and *Phragmites* stems are common throughout. This sequence is indicative of channel infilling and abandonment, followed by overbank deposition. It has been radiocarbon dated to between 7810–7580 cal BCE (Beta-285288) and 3640–3380 cal BCE (Beta-285292) in BH69-L.

4.4 Palaeochannel (early to mid-Bronze Age)

This unit is characterised by very dark grey sandy silt in core samples BH88-L and BH99-L, with frequent gravel in BH88-L (Figure 6). These cores were collected from the west and south of the study area, respectively (Figure 7). This unit is recorded between 4.72 m (197.27 m a.s.l.) and 4.21 m depth (197.78 m a.s.l.) in BH88-L and between 4.79 m (197.87 m a.s.l.) and 4.71 m depth (197.95 m a.s.l.) in BH99-L (Figure 6). Whole and broken shells, woody remains (up to 2 cm x 1 cm) and fine plant matter (*Phragmites*) are common throughout. Radiocarbon age reversals recorded in BH88-L are probably due to reworking of older sediment under fluvial conditions. A date of 1680–1520 cal BCE (Beta-310888) has been derived from wood (as opposed to organic sediment) at 4.62 m depth (197.37 m a.s.l.), probably representing the true age of this horizon. In BH99-L, organic sediment at 4.75 m depth (197.91 m a.s.l.) has been dated to 1940–1700 cal BCE (Beta-310890). These findings suggest a channel was present in the west and south of the study area during the early to mid-Bronze Age.

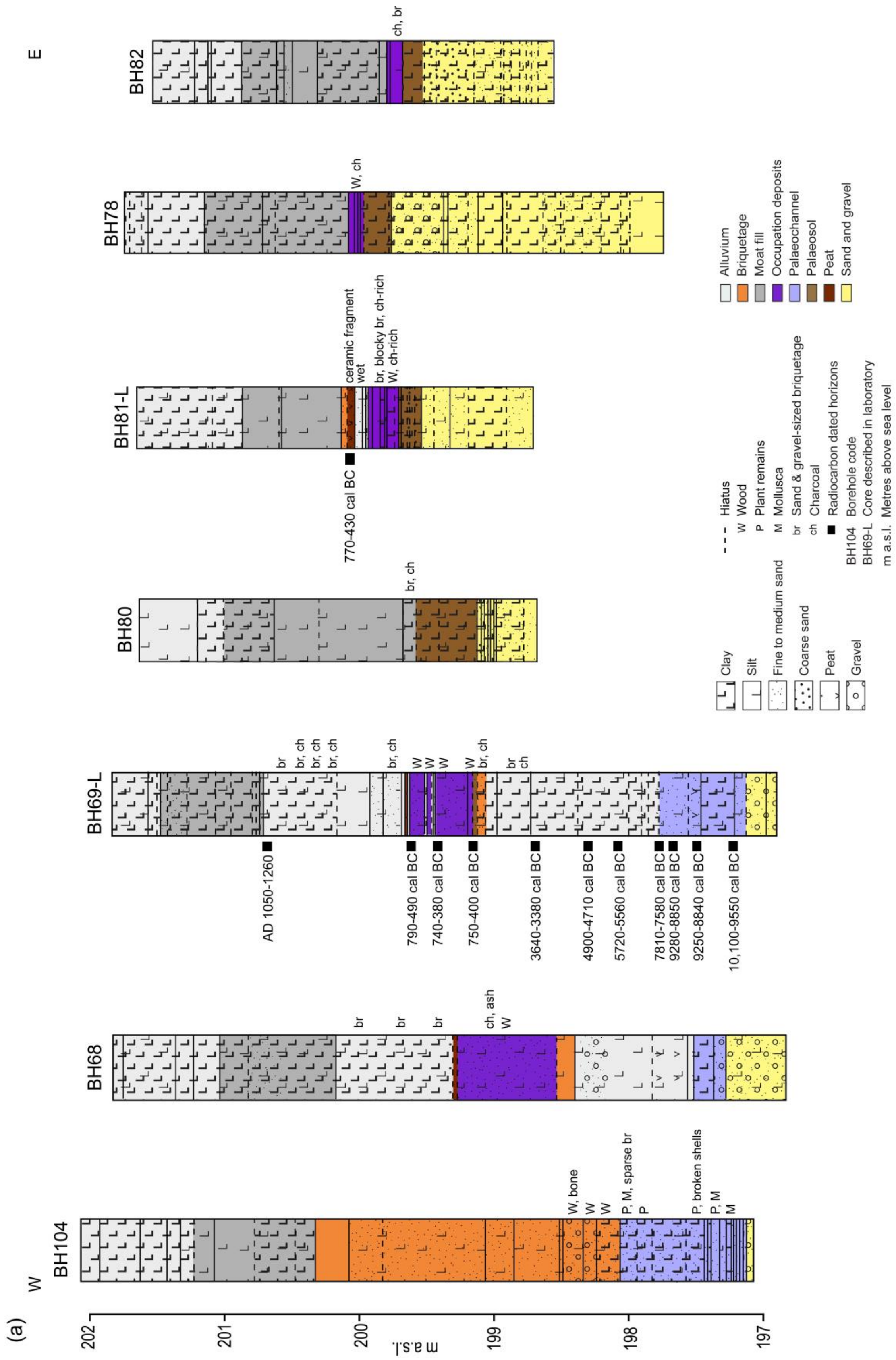

Figure 5(a): La Digue east—west sediment profile.

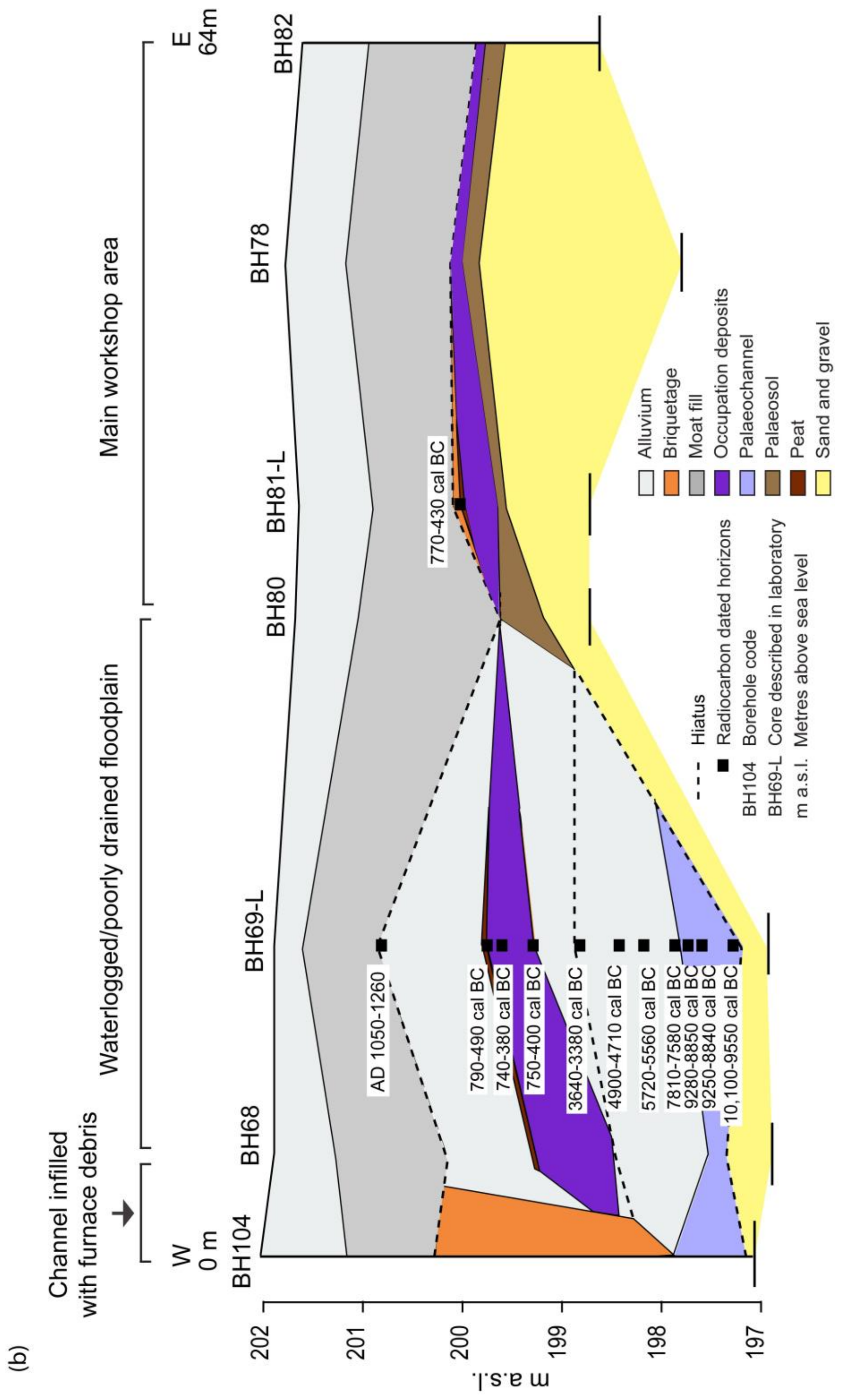

Figure 5(b): Schematic representation of La Digue east—west sediment profile, annotated to highlight features discussed in the text. The transect cuts through the main workshop area, established on a raised sand and gravel "terrace" in the east of the study area adjacent to waterlogged/poorly drained floodplain. A river channel infilled with briquetage is evident in the west of the profile (BH104: See also Figure 6).

4.5 Palaeosol (late Bronze Age)

This unit, which overlies sand and gravel in core samples BH78, BH80, BH81-L and BH82, is characterised by mottled dark grey and light grey stiff organic silty clay (Figure 5). It is present between 199.08 m a.s.l. (BH80) and 199.98 m a.s.l. (BH78). This unit has also been identified in BH52 (Table 1; Figure 7), where it has been radiocarbon dated from 1510–1300 cal BCE (Beta-266134) to 1260–1000 cal BCE (Beta-266133). It is thought to represent a palaeosol that developed on raised ground during relatively stable floodplain conditions. Pedogenesis may have extended into the underlying sand and gravel, where common mottling and root channels have been identified (see Section 4.1).

4.6 Occupation deposits (early Iron Age)

These comprise several units:

a. A thin layer (3—9 cm) of black charcoal-rich silt and clay overlies the late Bronze Age palaeosol in core samples BH78, BH81-L and BH82 (Figure 5). It is recorded between 199.57 m (BH81-L) and 200.01 m a.s.l. (BH78) and has been identified immediately below archaeological features such as furnaces and horizontally-bedded wooden structures during archaeological excavation (*e.g.*, Figure 4e—f). This unit is interpreted as an occupation deposit probably dating to establishment of the workshop. This occupation deposit is absent in BH80 (Figure 5), where dark brown silty clay containing occasional small charcoal and briquetage has instead been recorded (199.63—199.53 m a.s.l.), suggesting this area of the floodplain was outside the main production zone.

b. Dark grey and black silty clay have been recorded to the west of the palaeosol, between 198.38 m (BH68) and 199.56 m a.s.l. (BH69-L) (Figure 5). Fine-grained and blocky briquetage are recorded for the first time in these units, indicating that salt production had begun. Wood is also present (see Section 4.6c). These units are interpreted as poorly drained floodplain peripheral to the main activity zone and in proximity to the channel edge. Sparse, fine-grained briquetage and charcoal were initially deposited in BH69-L, probably under fluvial conditions, followed by blocky briquetage and wood, potentially signaling expansion of workshop activities onto the adjacent poorly drained floodplain.

c. Horizontally-aligned wood-rich horizons have been found in core samples throughout the study area (Figure 7), including those illustrated in Figure 5: BH78

(200.01—200.09 m a.s.l.); BH81-L (199.56—199.59 m a.s.l.); BH68 (198.15—199.29 m a.s.l.) and BH69-L (199.18 —199.56 m a.s.l.). Wood present in core samples from elevated ground in the east of the workshop (*e.g.*, BH78, BH81-L and BH82) probably corresponds to wooden remains found in this area during excavation (Figure 4e—f). These remains have been interpreted as a wood covering (probably brushwood and small branches) laid down to create a stable working surface in the salt extraction zone where settling tanks were located (Figure 7) (Olivier, 2014). The presence of wood in core samples at lower elevation, in proximity to the Iron Age channel (*e.g.*, BH68 and BH69-L), suggests extension of this feature onto wetter areas of the floodplain. Briquetage and charcoal are absent from the wood-rich horizons, implying different depositional conditions to those of the underlying and overlying alluvial units (described in Sections 4.6b and 4.6d, respectively). In BH69-L, wood alternates with fluvial (sand and gravel) and alluvial (clay) sub-units, also containing little or no briquetage and charcoal. This has similarly been recorded in BH66 and BH107, 6 m northeast and 12 m north of BH69-L, respectively (Figure 7). These sub-units have been radiocarbon dated to between 790 cal BCE and 380 cal BCE in BH69-L. Greater dating precision is not possible due to the radiocarbon plateau, however the archaeological stratigraphy and chronology suggest these horizons are contemporary with the workshop.

d. Wood-rich horizons are overlain by blocky briquetage and organic silty clay rich in briquetage, charcoal and ash between 199.6 m and 199.99 m a.s.l. in BH81-L (Figure 5). The sediment becomes increasingly sandy upwards and black peaty sandy silt containing a briquetage vessel sherd is recorded at 199.89—199.95 m a.s.l. This unit has been radiocarbon dated to 770–430 cal BCE (Beta-310885). Dark brown herbaceous peat and peaty silt have similarly been recorded above blocky briquetage in BH68 (Section 4.6b) and clay-rich silt in BH69-L (Section 4.6c), between 199.31—199.37 m a.s.l. and 199.67—199.675 m a.s.l., respectively.

4.7 Briquetage channel fill (early Iron Age)

This unit is present in cores BH77, BH97, BH99-L, BH100, BH104 and BH105 (Figure 6) and is characterised by very dark greyish black sandy silt and gravel containing increasing amounts of fine-grained and blocky briquetage and charcoal, and compacted sub-units of reddish-orange blocky briquetage. Large isolated fragments of horizontally-bedded wood (6 cm x 1 cm) and bone (4 cm x 3 cm) have been recorded toward the base of the unit in BH104 (Figures 5 and 6). Briquetage channel fill has been recorded between 197.56 m a.s.l. (BH77) and 201.64 m a.s.l.

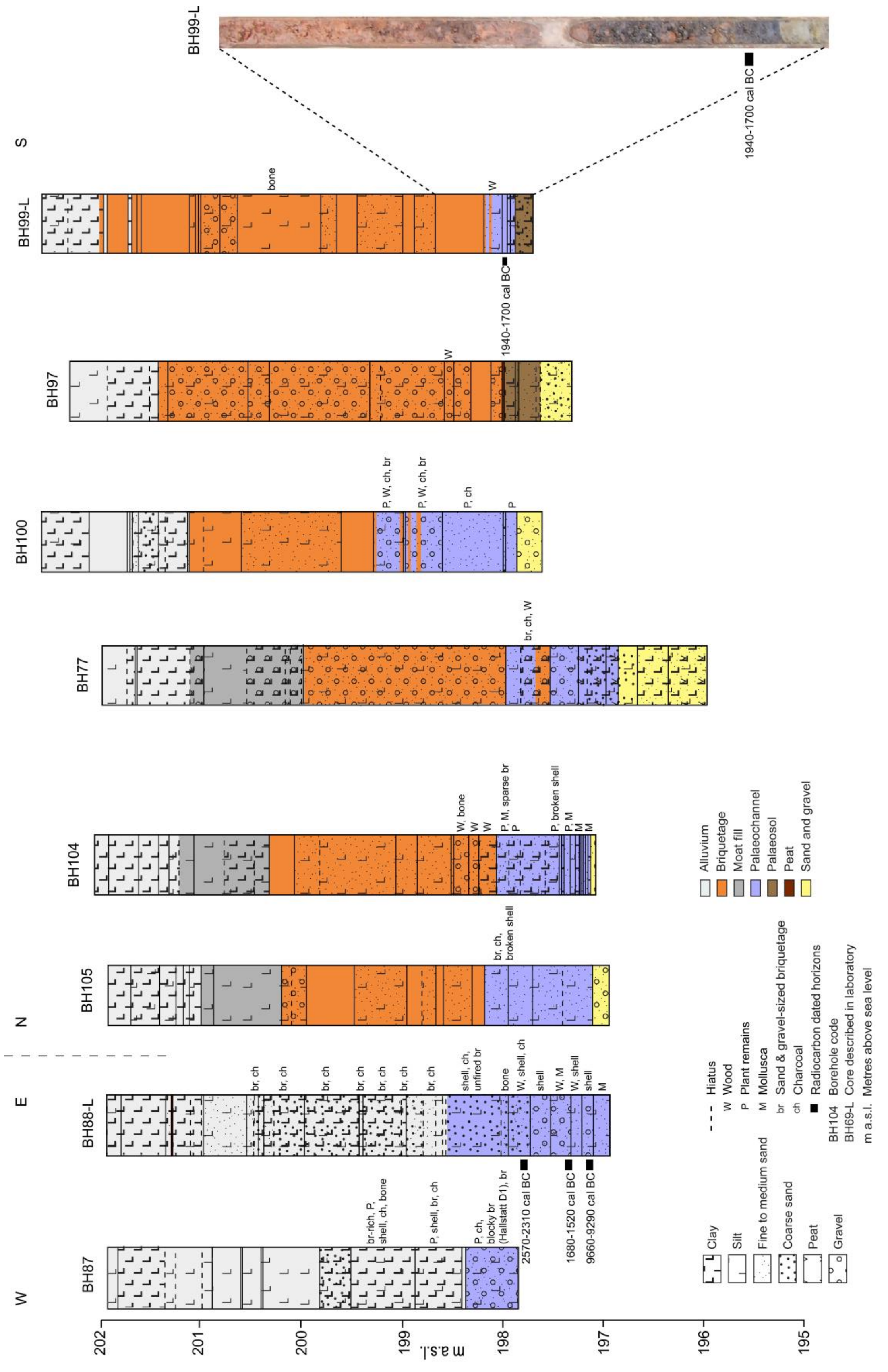

Figure 6: La Digue core samples containing evidence for early Iron Age channel deposits and in-channel briquetage accumulation. These cores have been used to determine the approximate location of the early Iron Age river thalweg, illustrated in Figure 7.

(BH99-L), and this unit ranges in thickness from 2.37 m (BH104) to 3.69 m (BH99-L). The briquetage has been typologically dated to the early Iron Age (Hallstatt D1), from the same period as the La Digue workshop. These results suggest the presence of a north—south orientated river channel, which became infilled with briquetage whilst the workshop was active. Common fine-grained and sparse blocky (Hallstatt D1) briquetage (BH87), charcoal, bone and wood (BH88-L) have also been identified in palaeochannel deposits to the west of the workshop (Figure 6). It is therefore likely that a second east—west orientated branch of the river was present during this period (Figure 7), which was unaffected by channel blockage.

4.8 Alluvium (post-Iron Age)

This unit is characterised by dark brown silty clay containing occasional decomposed plant matter and redeposited fine-grained briquetage and charcoal. Isolated fragments of blocky briquetage are also present, probably due to sediment disturbance associated with post-Iron Age development and fortification of Marsal village. It is recorded between 199.37 m and 200.75 m a.s.l. in cores BH68 and BH69-L (Figure 5), and the top of this unit has been radiocarbon dated to 1050–1260 CE (Beta-365359) in BH69-L. It is absent in other core samples due to a hiatus (visible as a sharp, erosional contact) caused by construction of a moat in 1699 (see Section 4.9).

4.9 Moat fill (post-17th Century)

This unit is characterised by soft, mottled light and dark grey, silt and clay containing varying amounts of laminated plant remains (*Phragmites* stems), decomposed plant matter, whole and broken shells and sand-sized briquetage. It is recorded in all core samples in the northeast of the study area, north of (and including) BH77 (Figure 7). It is therefore present in all of the sediment logs in Figure 5, where it occurs between 199.63 m (BH80) and 201.34 m (BH69-L) a.s.l. This moat was constructed during fortification of Marsal village in 1699 CE.

4.10 Alluvium (modern)

This unit is characterised by stiff dark greyish brown clay containing modern roots and common sand-sized briquetage. Redeposited blocky briquetage is also present due to recent sediment disturbance. This pedogenically altered alluvium is recorded between 200.57 m (BH81-L) and 202.66 m a.s.l. (BH99; BH100) (Figures 5 and 6).

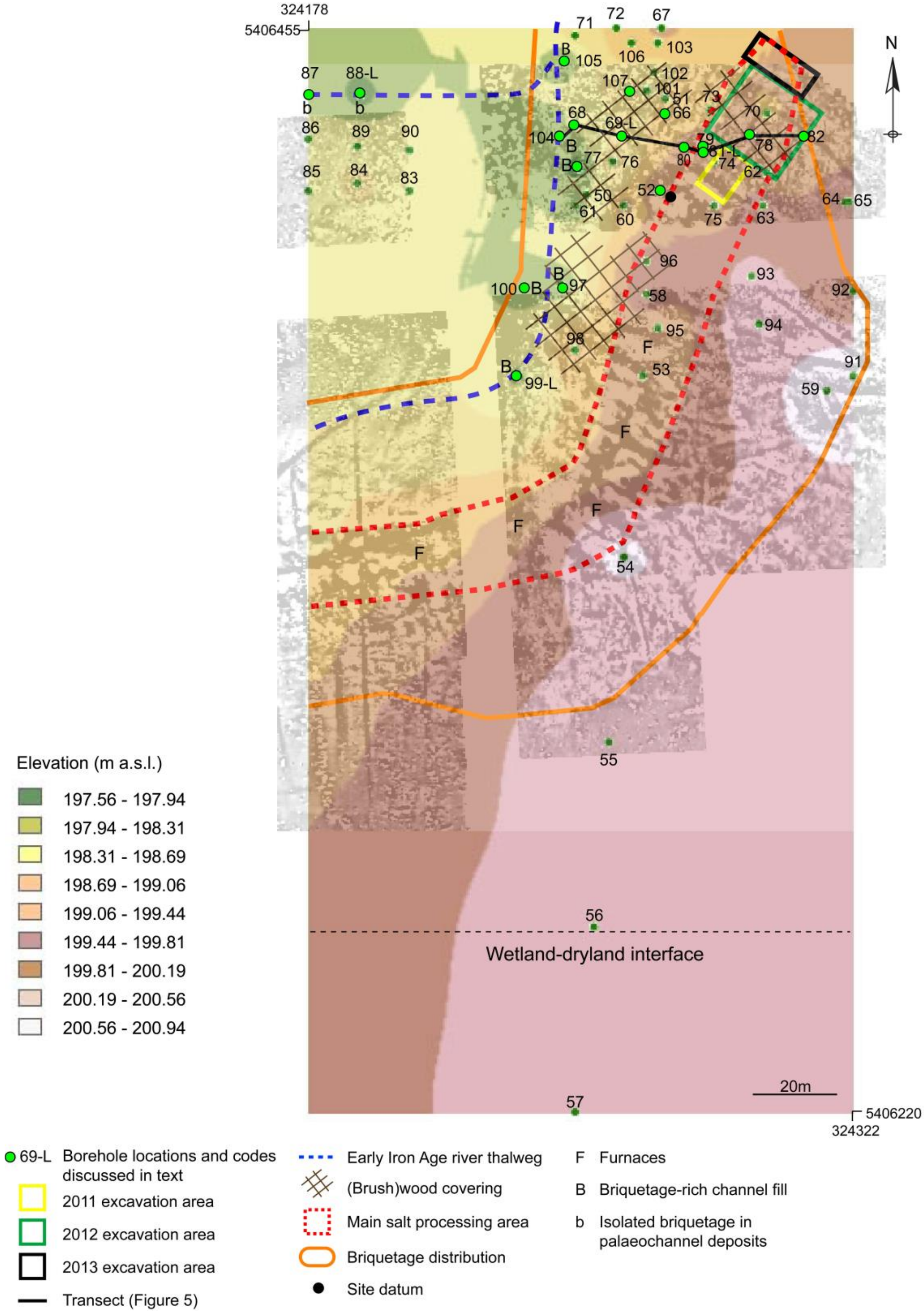

Figure 7: Topographic reconstruction of the base of Iron Age deposits and schematic map of the La Digue workshop area, overlain on geophysical survey results shown in Figure 3. White/black: +/- 5 nT, UTM 32N (WGS 84) coordinate system. Notable features identified as a result of excavation, borehole sampling, and the geophysical survey are illustrated.

5. Discussion

5.1 Environmental context of salt production in the Upper Seille Valley

It has been possible, based on these results, to reconstruct the palaeogeographic setting of the La Digue workshop and to establish a much clearer understanding of briquetage disposal practices and the relationship between the river and the workshop than has previously been achieved. The findings are as follows.

5.1.1 Palaeogeographic setting

The reconstructed early Iron Age topography and palaeogeographic setting of the La Digue workshop are illustrated in Figure 7. The results suggest a river has been present in the northwest of the study area since the Late Pleistocene, incising the Pleistocene sand and gravel and creating a northwest dipping land surface, with a raised sand and gravel “terrace” in the east. The lower part of the floodplain represents a pre-Holocene episode of erosional down-cutting from the level of the terrace, and subsequent Holocene aggradational infill of the depression created by this down-cutting. A river continued to be present in the study area into the Bronze Age and early Iron Age periods, with two branches identified in the borehole survey: North—south and east—west. The approximate location of the early Iron Age channels is illustrated in Figure 7. Findings from the borehole survey and excavation indicate that the La Digue workshop was established on raised ground adjacent to the north—south channel in ~625 cal BCE (Figure 7) (Olivier, 2010). Activity took place on the surface of a late Bronze Age palaeosol (1510–1300 cal BCE (Beta-266134) to 1260–1000 cal BCE (Beta-266133)) (199.1—200 m a.s.l.), which is likely to have formed under relatively dry stable conditions. This locality was probably selected for the workshop because it was above the maximum flood level (hence palaeosol development) and the substrate was naturally well-draining, providing dry conditions essential for salt production in an otherwise poorly drained environment. These findings are directly comparable to those from Pransieu, where salt production became established on a contemporary palaeosol (1450 —1270 cal BCE; 3400—3220 cal BP (Wk-212899)) (198.2—200 m a.s.l.), overlying Pleistocene sand and gravel terraces (Riddiford *et al.*, 2012). These locational characteristics are therefore probably typical of early Iron Age workshops in the Upper Seille Valley.

Waterlogged/poorly drained floodplain has been identified on lower ground peripheral to the main activity zone at La Digue (Figure 7) and the presence of fluvially-redeposited briquetage and charcoal in the sedimentary sequence suggests flooding took place whilst the workshop was active. This was followed by expansion of activities onto the poorly drained floodplain, evident from accumulation of blocky *in-situ* briquetage and construction of a (brush)wood covering. Briquetage and wood were probably used to create a stable working surface on otherwise waterlogged ground. The (brush)wood covering appears to have extended down slope from the north of the workshop onto the poorly drained floodplain, where it then ran parallel to the north—south channel (Figure 7). It was therefore probably used to provide access between the workshop and the river.

5.1.2 Briquetage disposal practices and consequences

Briquetage distribution at La Digue has been inferred from the presence/absence of briquetage in the sedimentary record and from geomagnetic prospection (Figure 7). It provides a crude indication of the spatial extent of workshop activities. The most significant finding from this site is the presence of thick accumulations of anthropogenic debris (primarily briquetage) in and overlying early Iron Age palaeochannel deposits, offering a much clearer understanding of briquetage disposal practices during the initial phase of this industry than has hitherto be achieved. It provides clear evidence for channel infilling, initially hypothesised from indirect sedimentary evidence at Pransieu (Riddiford *et al.*, 2012). Overall, these findings imply it may have been common practice to dispose of briquetage and associated salt production waste into the river at early Iron Age workshops. This would explain the widespread distribution of sand and gravel-sized briquetage in the sedimentary record.

At La Digue, these accumulations are particularly evident in the north—south channel, and the density and thickness of the debris, contemporary with the workshop, suggest rapid and deliberate channel blockage. This coupled with the presence of an artificial (brush)wood surface adjacent to the channel highlight an important and previously unrecognised relationship between the workshop and the river. Briquetage may have been used to stablise the river bank, providing access to the channel, possibly for navigation. However, subsequent channel blockage would have prevented long term use of the river for this purpose. Alternatively, salt workers may have attempted to divert flow to the east—west channel, which appears to have passed to the north of the workshop (Figure 7). This may have been done with the intention of expanding activities onto lower, poorly draining, parts of the floodplain and/or reducing flood risk by increasing the distance of the workshop to the river. Jusseret *et al.* (2015) have found supporting evidence for northward migration of the river during this period: Palaeochannel deposits have been identified across a ~150 m stretch of the floodplain, beginning in the northeast of the La Digue study area and extending towards Marsal village (the location of this transect is illustrated in Figures 2 and 3). Early Iron Age briquetage has been identified in these deposits at La Digue, whilst late Iron Age briquetage has been found near Marsal, corresponding to the known locations of early and late Iron Age salt workshops, respectively (Olivier and Kovacik, 2006). These results suggest that significant channel migration occurred during the Iron Age, and this was potentially influenced by briquetage disposal and associated river management. As hypothesised at Pransieu (Riddiford *et al.*, 2012), channel blockage is likely to have considerably disrupted the fluvial regime, probably triggering increased flood frequency and waterlogging, making it extremely difficult to sustain salt production over the long term. Greater sediment input from catchment-wide soil erosion (arising from intensive salt production, agriculture and deforestation (Riddiford *et al.*, 2012)) is also likely to have further lowered the channel capacity, thereby contributing to increasing flood frequency. The fluvial response was probably exacerbated by pronounced climatic deterioration, elevated groundwater and heightened flood intensity that affected the region in ~800—500 cal BCE (Notebaert & Verstraeten, 2010; Zolitschka *et al.*, 2003), increasing sensitivity of the Upper Seille Valley hydrological system to disturbance.

New findings from La Digue provide localised evidence for increased channel mobility and/or flooding whilst the workshop was active, probably arising (at least partially) from in-channel briquetage disposal. Alternating horizons of natural alluvium and (brush)wood could imply periodic abandonment of activities along the channel edge, followed by reoccupation, in response to variable channel conditions. This could potentially be related to either seasonal (spring/summer) production to avoid winter flooding, or longer periods of abandonment due to increased flood frequency and intensity, which eventually led to permanent abandonment in ~500 cal BCE. Workshop activity at La Digue appears to have ended following a major flood event, after which peat developed, implying impeded drainage. This has been archaeologically dated to ~500 cal BCE (Olivier, 2014) and potentially corresponds to the onset of widespread marsh development in the Upper Seille Valley, inferred from a rapid and sustained increase in Cyperaceae pollen that began in ~500–250 cal BCE (2450–2200 cal BP) (Riddiford *et al.*, 2012). This reflects a major hydrological shift towards wetter floodplain conditions, probably resulting from a combination of natural and anthropogenic factors. Valley-wide workshop abandonment by the early 5th century cal BCE could have occurred in response to development of a more dynamic floodplain environment, with increased river mobility, waterlogging and inundation, potentially accompanied by a reduction in the number and concentration of brine springs. Nevertheless, socio-political changes (suggested by the simultaneous collapse of early Iron Age “princely” centres throughout northwest Europe) cannot be discounted (*cf.* Olivier, 2000). Salt-making activities were subsequently relocated to Marsal, Moyenvic and Vic-sur-Seille (Figure 2), where substantial briquetage deposits accumulated, forming artificial “islands” on the floodplain. Production took place on these features, raising workshops above waterlogged ground. This probably facilitated expansion and intensification of the industry in an otherwise potentially unfavourable environment.

5.2 Wider implications

Review of the literature suggests there are notable similarities between geographical characteristics and transformation of the Upper Seille Valley from a natural to cultural landscape with those of other early inland and coastal salt-making sites dating from the Bronze Age to Roman periods (Figure 1) (*e.g.*, Bell *et al.*, 1999; Bradley, 1992; de Brisay and Evans, 1975; Fawn *et al.*, 1990; Flad *et al.*, 2009; Lane and Morris, 2001; Nevell and Fielding, 2005; Went, 2011; Woodiwiss, 1992). These sites are also likely to have been influenced by pronounced climatic deterioration and hydrological (including relative sea level) changes occurring throughout northwest and central Europe at this time (*e.g.*, Biddulph *et al.*, 2012; Bradley, 1992; Fawn *et al.*, 1990; Healey, 1999; Lane and Morris, 2001; Went, 2011). Together, this highlights the importance of understanding the environmental context of these sites and raises important questions for future research.

Inter-site comparisons clearly indicate a close relationship between salt production and hydrology: Workshops were typically located in wetland environments in proximity to salt source and water courses (rivers, tidal channels) (Bradley, 1992; Connelly and Power, 2005; Dodds, 2005; Fawn *et al.*, 1990; Flad *et al.*, 2009; Garner, 2005; Healey, 1999; Kinory, 2012; Kleinmann, 1975; Lane, 2005; Nevell, 2005; Tessier, 1975; Thoen, 1975; Went, 2011; Woodiwiss, 1992). As in the Upper Seille Valley, these sites were inherently vulnerable to waterlogging and flooding, conflicting with the essential need for dry conditions to prevent dilution of brine solutions, dousing of furnace fires and re-hydration of salt crystals (Connelly and Power, 2005; Fawn *et al.*, 1990; Gurney, 1999; Nevell, 2005; Fielding, 2005; Woodiwiss, 1992). Nevertheless, it was not uncommon for production to continue for hundreds of years (*e.g.*, Jülich, 2005; Lane, 2005; Martin, 1975; Nevell, 2005; Thoen, 1975; Woodiwiss, 1992). The approaches taken to mitigate the threat of flooding in the Upper Seille Valley were probably widely adopted: Findings from La Digue suggest that subtle differences in topography and relative vulnerability of areas to waterlogging and flooding influenced site organisation, possible seasonal production, and allocation of activity zones. These zones are characteristic features of early intensive salt-making sites (*e.g.*, Arrowsmith and Power, 2012; Connelly and Power, 2005; Flad *et al.*, 2009; Gurney, 1999; Jűlich, 2005; Lane, 2005; Woodiwiss, 1992). Salt extraction and processing activities seem to have typically been restricted to naturally-elevated well-draining ground and/or areas protected by natural flood barriers, such as levees and coastal dunes (*e.g.*, Fawn *et al.*, 1990; Garner, 2005; Kleinmann, 1975; Kondo, 1975; Thoen, 1975; Went, 2011; Woodiwiss, 1992). Wood-lined ditches were often used to transport brine from source to processing areas (*e.g.*, Arrowsmith and Power, 2012; Dodds, 2005; Garner, 2005; Gurney, 1999; Lane, 2005; Woodiwiss, 1992) and it has been suggested at a small number of sites that ditches were used to drain marginal areas to create suitable conditions for salt production, implying water management (Garner, 2005; Woodiwiss, 1992). This practice may have been more widespread than is currently recognised.

It seems that briquetage was commonly used to create stable working surfaces on waterlogged ground, allowing expansion of workshop areas (*e.g.*, Biddulph *et al*., 2012; Healey, 1999; Flad *et al.*, 2009; Garner, 2005; Went, 2011; Woodiwiss, 1992). In the Upper Seille Valley this has been shown to include in-channel briquetage disposal and anthropogenically-induced channel migration, which (coupled with naturally deteriorating environmental conditions) had unintended, yet inevitable, hydrological consequences that potentially contributed to permanent site abandonment. Waste disposal on the edges of, and into, water courses (ditches, rivers and tidal creeks) has also been noted at a small number of other salt workshops, where it has been linked in some cases to site expansion and/or land reclamation. However, this has received little more than a passing comment: Sites include Chidham (West Sussex, UK) (Bradley, 1992); Helpringham Fen (Lincolnshire, UK) (Healey, 1999); the Wash (East Anglia, UK) (Went, 2011); Stanford Wharf (Essex, UK) (Biddulph *et al*., 2012); and Zhongba (Chongqing City, China) (Flad *et al.*, 2009; ZhiBin, 2008). Given the proximity of salt-making sites to water courses and the large volume of waste produced by this activity, it is feasible that briquetage entered the fluvial environment more often than has currently been documented. The likely hydrological implications of this, highlighted by findings from the Upper Seille Valley, emphasises the importance of investigating this further. Using briquetage to artificially raise working surfaces may also have been a common adaptation to increasingly wet conditions: Workshops have frequently been identified on top of briquetage deposits, although these are smaller than the late Iron Age mounds identified in the Upper Seille Valley (Bestwick, 1975; Biddulph *et al*., 2012; Dodds, 2005; Fawn *et al.*, 1990; Flad *et al.*, 2009; Healey, 1999; Kondo, 1975; Lane, 2005; Went, 2011; Woodiwiss, 1992). This practice is potentially analogous to coastal and riverine "dwelling mounds" in Germany and the Netherlands, constructed from the early Iron Age onwards to provide protection to settlements during episodes of severe flooding (*e.g.*, van Geel *et al*., 1998; Meier, 2004; Schepers *et al.*, 2013). Further research is however required to test this hypothesis.

Many coastal and inland salt-making sites were abandoned and subsequently buried by sediment when increased flooding could no longer be successfully mitigated, socio-political structures sustaining salt production activities collapsed, and/or new salt production technologies arose and changed. Added to this is the possible (and important) impact of hydrological changes on brine availability at inland sites, which has yet to be investigated in this context. Increased flooding has primarily been attributed to regional alterations in the hydrological regime triggered by climate change, rising relative sea level and human activities such as agriculture and associated woodland clearance (*e.g.*, Biddulph *et al*., 2012; Bradley, 1992; Fawn *et al.*, 1990; Gurney, 1999; Healey, 1999; Lane, 2005). However, the findings presented here suggest that salt-making activities may also have significantly contributed to this, through modification of the local hydrological regime, and increased sediment supply as a result of environmental disturbance at workshops (*e.g.*, soil erosion) and in the wider landscape (*e.g.*, fuel utilisation leading to deforestation) (Dufraisse, 2002; Dufraisse and Gauthier, 2002; Lane and Morris, 2001; Pétrequin *et al*., 2001; Riddiford *et al.*, 2012). The palaeoenvironmental context of these sites therefore deserves more attention, due to new insights this can offer into human—environment interactions and consequences of early intensive salt production.

6. Conclusion

High-resolution borehole sampling coupled with conventional excavation and geophysical surveying has built on and refined previous investigations described in Riddiford *et al.* (2012). It has enabled the palaeogeographic setting of early Iron Age salt production activities at La Digue to be established and detailed insights into human—river interactions to be identified, enhancing current understanding of this important early industry. It has permitted detailed reconstruction of the local landscape and identification of changes in the floodplain environment directly related to salt-making, which would not have been possible otherwise. Establishing a natural baseline of hydrological and environmental changes prior to the onset of salt production was pivotal to determining this. The findings presented here suggest there was deliberate use of the landscape to the benefit of salt production (with unintended consequences) and that a close relationship existed between salt-making and the local hydrological regime. Water management was probably integral to this activity in the Upper Seille Valley, raising important questions about the extent to which this was practiced at other salt-making sites and how it affected hydrology, particularly during periods of climatic change when there was heightened environmental sensitivity to human disturbance. These findings also draw attention to the importance of understanding briquetage disposal practices, which have been largely overlooked elsewhere. The enormous quantity of waste generated by the briquetage technique had the potential to significantly alter the environment and landscape of salt production sites. These impacts were probably more widespread than is currently recognised given the large number and scale of salt-making sites from the Iron Age onwards. As such, we would argue that the *environmental* context and implications of this activity are equally worth considering alongside currently prevailing technological, social and economic questions. Moreover, there is clearly a need to extend geoarchaeological investigations of human interactions with, and impacts on, river systems (including floodplain exploitation and management of water resources) to encompass early intensive salt production.

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Supplementary material

Sediment core descriptions for "La Digue" (Upper Seille Valley, Lorraine, France)

Borehole codes and grid references are given for each core sample. Elevation is presented in meters above sea level (m a.s.l.). All cores were described in the field, with the exception of BH69-L, BH81-L, BH88-L and BH99-L, which were described in the laboratory and sampled for radiocarbon dating. Radiocarbon dated horizons and results are highlighted in bold in the relevant tables.

Table 1: BH52 (32N 324271, 5406411)

Elevation (m a.s.l.)	Description
202.04–192.04	Dark brown; pedogenically altered alluvium; briquetage; frequent rooting
192.04–201.85	Dark brown silty clay; frequent rooting
201.85–201.76	Grey brown silty clay; briquetage
201.76–201.63	Dark brown silty clay; large fragments of briquetage
201.63–201.26	Dark grey silty clay; frequent charcoal, briquetage
201.26–201.22	Layer of briquetage
201.22–201.19	Light yellowish brown clay; charcoal present
201.19–201.12	Dark grey silty clay; charcoal and briquetage inclusions
201.12–200.88	Briquetage layer
200.88–200.81	Light yellowish brown silty clay with small gravel; occasional charcoal
200.81–200.68	Dark brown silty clay; charcoal, briquetage and bone
200.68–200.30	Dark grey brown silty clayey gravel; small briquetage and charcoal
200.30–200.27	Dark grey silty clay; small charcoal
200.27–200.18	Dark grey brown silty clayey gravel; small briquetage and charcoal
200.18–200.17	Dark grey silty clay; small charcoal
200.17–200.14	Dark grey brown silty clayey gravel; small briquetage and charcoal
200.14–200.13	Dark grey silty clay; small charcoal
200.13–	Dark grey brown silty clayey gravel; small briquetage and charcoal

199.59	
199.59–199.46	Dark brown/black silty clay (pedogenically altered alluvium) **1260–1000 cal BCE (Beta–266133): 199.58–199.56 m a.s.l.** **1510–1300 cal BCE (Beta–266134): 199.48–199.46 m a.s.l.**
199.46–198.82	Dark blue grey silty clay with occasional gravel; infrequent organic matter
198.82–198.44	Mottled reddish brown and yellowish brown silty clay
198.44–198.22	Mottled reddish brown and yellowish brown clayey sandy silt
198.22–198.18	Blue grey silty clay
198.18–197.74	Mottled reddish brown and yellowish brown clayey sandy silt
197.74–197.19	Yellowish brown silty sandy gravel
197.19–196.67	Mottled very dark brown/black–dark grey silty clay with fine sand and gravel; possibly organic-rich soil/sediment
196.67–196.48	Black peat; highly decomposed and compacted
196.48–196.42	Yellowish brown silty sandy clay; pellets of grey clay and Manganese
196.42–196.39	Dark grey and orange clay with fine gravel
196.39–196.25	Olive green sandy silt with fine gravel
196.25–196.04	Light grey sandy silty gravel

Table 2: BH68 (32N 324249, 5406429)

Elevation (m a.s.l.)	**Description**
201.84–201.78	Dark greyish brown; pedogenically altered alluvium; clayey silt; common modern roots; sharp boundary to
201.78–201.38	Dark reddish brown; pedogenically altered alluvium; silty clay with inclusions of briquetage, slate and limestone; sharp to
201.38–201.24	Grey clay containing small fragments of briquetage; reduced? Sharp to
201.24–201.04	Mottled reddish–brown greyish–brown clay containing root channels and plant macrofossils; oxidised? Sharp to
201.04–200.77	Bedded light to dark grey silty clay containing plant macrofossils; reduced; common plant macrofossils (*Phragmites* stems); gradual boundary to
200.77–200.10	Bedded dark grey silty clay containing occasional plant macrofossils and sand-sized briquetage; bed of sand and sand-sized briquetage in silty matrix from 200.77–200.58; sharp to
200.10–199.37	Dark grey silty clay containing blocky briquetage and charcoal; lens of light greenish grey clay between 199.99–199.96; gradual to
199.37–199.31	Dark brown herbaceous peat; gradual to
199.31–199.29	Blocky briquetage; gradual to

199.29–198.52	Mottled grey to dark grey to very dark brown organic sandy silt containing wood macrofossils and sedge grass remains; black charcoal and ash layer between 199.02–198.98; gradual to
198.52–198.38	Dark grey silty clay containing blocky briquetage; sharp to
198.38–197.84	Mottled light to dark grey organic clayey silt containing very fine plant matter throughout; olive grey gravelly sand layer at 198.32–198.20; small wood fragments at 198.33 and 198.15; gradual to
197.84–197.58	Light grey silty clay containing dark brown peat and fine plant matter; possibly alluvium containing redeposited peat; sharp to
197.58–197.51	Dark brown peat becoming increasingly silty towards base (197.54–197.51); contains very fine plant matter; sharp to
197.51–197.38	Olive grey clay containing fine plant matter and shell fragments; gradual to
197.38–197.30	Mottled olive grey to light grey fine sandy gravel in silty matrix; contains shell fragments and fine plant matter; sharp to
197.30–196.84	Light grey silty sandy gravel

Table 3: BH69-L (32N 324261, 5406426)

Elevation (m a.s.l.)	Colour	Description
201.83–201.64	7.5YR 3/1 Very dark grey	Pedogenically altered alluvium containing modern roots and sand and fine gravel-sized briquetage (maximum 0.2 cm); sharp to
201.64–201.56	5YR 8/1 White	Horizontally bedded blocky white lithology (limestone masonry). Blocky briquetage at 201.61–201.59 and 201.59–201.58 (5YR 6/8 Reddish yellow); gradual to
201.56–201.54	5YR 6/8 Reddish yellow	Blocky briquetage (continuation of above, but no limestone); sharp to
201.54–201.49	7.5YR 4/3 Brown	Sandy silty clay containing sand and gravel-sized briquetage and occasional small limestone clasts (up to 0.5 cm); modern roots; gradual to
201.48–201.34	5YR 4/2 Dark reddish grey	Silty clay containing sparse modern roots and fine gravel-sized briquetage and limestone (≤1 mm); blocky briquetage (0.5–1.5 cm) in a silty clay matrix at 201.38–201.34; gradual to
201.34–201.11	7.5YR 4/1 Dark grey	Silty clay containing blocky briquetage at 201.32–201.26; charcoal fragments at 201.33–201.32 and 201.25; blocky limestone at 201.34–201.33, 201.32, 201.31 and 201.19; small limestone fragments and sparse gravel-sized briquetage (<0.1 cm) throughout; gradual to
201.11–201.00	2.5Y 4/3 Olive brown	Mottled clay containing crumbling briquetage fragments (~0.3 cm) and charcoal throughout; gradual to
201.00–200.80	2.5Y 2.5/1 Black	Faintly mottled clay containing crumbling briquetage (0.1–1 cm) and small limestone fragments (~0.1 cm); occasional charcoal throughout; horizontally bedded block of briquetage (2 cm x 4 cm) at 200.83–200.81; gradual to
200.80–200.77	2.5Y 2.5/1 Black	Silt containing horizontal plant beds (*Phragmites* stems) between 200.80–200.79; sharp to

200.77–200.75	2.5Y 5/1 Grey	Mottled silt; sharp to
200.75–200.23	7.5YR 4/2 Brown	Clayey silt rich in briquetage; occasional charcoal fragments present throughout (*e.g.,* at 200.49–200.48); sand and gravel-sized briquetage (0.1–0.5 cm) common; blocky briquetage (1 cm x 2cm to 3 cm x 2 cm) at 200.57–200.55, 200.47–200.42 and 200.35–200.24; gradual to **1050–1260 CE (Beta-365359): 200.74–200.72 m a.s.l.**
200.23–199.95	7.5YR 3/1 Very dark grey	Silt rich in blocky and gravel-sized briquetage; large charcoal fragments at 200.12–200.10 and 200.08–200.06; charcoal-rich layer at 199.98–199.95; sharp to
199.95–199.83	2.5Y 3/2 Very dark greyish brown	Sandy silt with horizontal charcoal layers at 199.93, 199.92, 199.91–199.88 and 199.86–199.83; sand layer at 199.88–199.87; blocky briquetage at 199.95–199.93, 199.90, 199.85 and 199.83
199.83–199.68	2.5Y 2.5/1 Black	Fine sandy silt; small clay lens (or disintegrated briquetage) at 199.81 (2.5Y 6/4 Light yellowish brown); small charcoal fragments (~5 mm) and sand and gravel-sized briquetage throughout; large horizontal charcoal fragment (2 cm x 0.5 cm) at 199.70; horizontally–bedded blocky briquetage at 199.70–199.68; sharp to
199.68–199.675	2.5Y 6/4 Light yellowish brown	Clay; sharp to
199.675–199.67	7.5YR 2.5/1 Black	Peaty silt; sharp to
199.67–199.66	2.5Y 6/4 Light yellowish brown	Clay-rich silt; silty clay lens (disintegrated briquetage?) 1 cm x 0.5 cm at 199.67–199.66 (7.5YR 6/8 Reddish yellow); sharp to
199.66–199.55	7.5YR 2.5/1 Black	Sandy silt becoming silty sand downwards; 1.5 cm x 0.5 cm black peat fragment in silty sand at 199.62–199.60; sparse coarse sand–fine gravel at 199.57–199.55; woody fragment (1.5 cm x 1 cm) at 199.56–199.55 (archaeology); sharp to **790–490 cal BCE (Beta–285295): 199.63–199.61 m a.s.l.**
199.55–199.54	2.5Y 5/1 Grey	Clay; sharp to
199.54–199.50	2.5Y 2.5/1 Black	Silty clay becoming increasingly sandy downwards; horizontal wood fragment (3.5 cm x 0.5 cm) at 199.53–199.525 (archaeology); horizontal clast (2 cm x 0.5 cm) at 199.525–199.52; sandy silt between 199.52–199.50; gradual to
199.50–199.48	2.5Y 2/1 Black	Silty clay rich in horizontally bedded woody remains 0.5 cm x 1 cm (archaeology); sharp to
199.48–199.47	2.5Y 4/2 Dark greyish brown	Sandy gravely silt rich in coarse sand and fine gravel; sharp to
199.47–199.22	2.5Y 2/1 Black	Fine sandy silt very rich in horizontally bedded wood (archaeology); fragments up to 1.5 cm x 3 cm; peaty between 199.24–199.22; wood small and sparse between 199.24–199.22; sharp to

		740–380 cal BCE (Beta–285294): 199.46–199.44 m a.s.l.
199.22–199.18	2.5Y 4/1 Dark grey	Silt containing sparse small wood fragments and coarse gravel up to 0.5 cm; large horizontal wood fragment (2 cm x 0.5 cm) at 199.185–199.18 (archaeology); gradual to
199.18–199.15	2.5Y 4/1 Dark grey	Disaggregated/crumbly fine sandy silt containing scattered fine plant matter (*Phragmites* stems); gradual to **750–400 cal BCE (Beta–285293): 199.18–199.16 m a.s.l.**
199.15–199.09	2.5Y 4/1 Dark grey	Sandy silty clay containing blocky briquetage (up to 1 cm) and charcoal throughout; gradual to
199.09–199.00	2.5Y 5/3 Light olive brown	Silty clay containing scattered charcoal and fine gravel-sized briquetage (~0.3 cm); briquetage is increasingly sparse and smaller downwards; sharp to
199.00–198.74	7.5YR 4/1 Dark grey	Clay containing sparse very fine gravel/coarse sand-sized briquetage (<0.2 cm) and charcoal throughout; gravel-sized briquetage (1 cm x 1.5 cm) at 198.945–198.935; clay containing sparse small charcoal fragments (0.1–0.2 cm); gradual to
198.74–198.37	7.5YR 4/1 Dark grey	Clayey silt containing sparse fine plant matter (*Phragmites* stems) below 198.48; gradual to **3640–3380 cal BCE (Beta–285292): 198.71–198.69 m a.s.l.**
198.37–197.99	7.5YR 4/1 Dark grey	Clayey silt containing fine plant matter throughout (*Phragmites* stems); gradual to **4900–4710 cal BCE (Beta–285291): 198.28–198.26 m a.s.l.** **5720–5560 cal BCE (Beta–285290): 198.05–198.03 m a.s.l.**
197.99–197.89	7.5YR 3/1 Very dark grey	Clayey silt containing occasional plant remains (*Phragmites* stems); intact horizontally bedded Mollusc shell at 197.905 (0.3 cm x 0.2 cm); gradual to
197.89–197.83	7.5YR 2.5/1 Black	Peaty silty clay containing common plant remains (*Phragmites* stems)
197.83–197.75	2.5Y 3/1 Very dark grey	Peaty silty clay containing occasional fine woody remains; gradual to **7810–7580 cal BCE (Beta–285288): 197.77–197.74 m a.s.l.**
197.75–197.53	2.5Y 4/2 Dark greyish brown	Fine sandy silt becoming increasingly sandy downwards; Mollusca common below 197.62; horizontally bedded whole shell (1.5 cm) at 197.62; horizontal charcoal fragment (1.5 cm x 0.3 cm) at 197.54; fine roots present between 197.60–197.53; gradual to **9280–8850 cal BCE (Beta–285287): 197.64–197.62 m a.s.l.**
197.53–197.43	2.5Y 3/1 Very dark grey	Peaty sandy silt rich in horizontally bedded whole and broken Mollusca; shell bed at 197.47–197.46; horizontally bedded plant remains below 197.50; relatively sharp to **9250–8840 cal BCE (Beta–285286): 197.46–197.43 m a.s.l.**
197.43–197.17	2.5Y 4/2 Dark greyish brown	Silty clay containing horizontally bedded plant remains throughout (less frequent below 197.26); increasingly silty downwards, becoming clay-rich silt below 197.26; common whole and broken Mollusca between 197.43–197.37 (less frequent below 197.37); whole Mollusca at 197.32 and

		197.30; sparse Mollusca between 197.26–197.22, more frequent again from 197.22–197.17; sharp to **10,100–9550 cal BCE (Beta–285285): 197.19–197.16 m a.s.l.**
197.17–197.09	2.5Y 4/1 Dark grey	Silty fine sand rich in Mollusca; fine gravel below 197.14; wood at 197.15 and possibly a root or branch (1 cm x 0.5 cm) at 197.13–197.12 (cut through during coring); gradual to
197.09–196.87	2.5Y 5/1 Grey	Sandy gravel increasing in grain size downwards; angular and rounded horizontally bedded gravel; woody fragment at 196.96–196.94; sharp to
196.87–196.83	2.5Y 2.5/1 Black	Silty sandy gravel

Table 4: BH77 (32N 324250, 5406417)

Elevation (m a.s.l.)	**Description**
202.01–201.77	Dark brown silt containing modern roots; pedogenically altered alluvium; blocky and gravel-sized briquetage between 201.93–201.77; gradual to
201.77–201.69	Dark brown stiff clay containing blocky and gravel-sized briquetage and modern roots; sharp to
201.69–201.62	Reddish–orange blocky briquetage and gravel-sized briquetage; sharp to
201.62–201.15	Dark brown stiff clay containing blocky and gravel-sized briquetage; limestone clast at 201.50–201.48; small limestone clasts and occasional charcoal throughout; charcoal layer at 201.15; gradual to
201.15–201.01	Dark greyish brown silty gravely clay containing limestone clasts and occasional charcoal; rich in plant macrofossils throughout
201.01–200.58	Dark greyish brown silt rich in plant macrofossils and fine plant matter; charcoal fragment at 200.82–200.81; gradual to
200.58–200.20	Dark grey gravely clay containing sand-sized briquetage and charcoal; common plant macrofossils throughout; shell fragments between 200.45–200.36; Mollusca between 200.30–200.28; gradual to
200.20–200.15	Dark grey sandy silty gravely clay containing sand and gravel-sized briquetage and common plant macrofossils throughout; gradual to
200.15–200.03	Dark grey silty gravely clay containing sand and gravel-sized briquetage; gradual to
200.03–200.01	Blocky briquetage and charcoal in a dark grey–black silty matrix
200.01–199.01	Wet slurry of blocky and gravel-sized briquetage and charcoal in dark greyish brown sandy gravely silt; drier between 199.17–199.01
199.01–198.01	Continuation of above; woody remains throughout, most common between 198.34–198.36; blocky briquetage fragment between 198.36–198.28
198.01–197.86	Dark brown to black organic sandy silt containing sand and gravel-sized briquetage and common plant macrofossils throughout; charcoal at 197.91; woody remains between 197.91–197.89; blocky briquetage fragment at 197.89–197.86; gradual to
197.86–197.56	Dark grey to black organic sandy silty gravely clay containing very fine plant matter and occasional sand-sized briquetage; blocky briquetage between 197.72–197.56; sharp to

197.56–197.28	Grey sandy silty gravel; sharp to
197.28–197.20	Dark greyish brown organic silty clay containing dark brown organic (peaty) beds at 197.25, 197.23, 197.22, 197.20, 197.21; shell bed (fragments) at 197.21; gradual to
197.20–197.01	Dark brown organic silty clay (peaty) containing shell fragments throughout and occasional fine gravel
197.01–196.88	Dark greyish brown organic silty clay (peaty) containing very fine plant matter and occasional fine gravel; common Mollusca and shell fragments throughout; sharp to
196.88–196.69	Wet light brownish grey sandy silty gravel; rounded clasts to 196.75 becoming coarse angular gravel between 196.75–196.69; sharp to
196.69–196.39	Dark grey sandy clay; common fine plant matter and macrofossils throughout; occasional fine gravel and black flecks; sharp to
196.39–196.01	Dark greyish brown to black organic sediment (peaty sandy silty clay) containing fine gravel; white fine sand lens at 196.32

Table 5: BH78 (32N 324301, 5406413)

Elevation (m a.s.l.)	**Description**
201.77–201.72	Grey clay containing common sand-sized briquetage fragments; gradual to
201.72–201.63	Blocky briquetage in grey clay matrix; gradual to
201.63–201.58	Grey clay containing common sand-sized briquetage fragments; sharp to
201.58–201.16	Grey sandy clay rich in blocky briquetage, especially between 201.44–201.33; scattered limestone clasts down to 201.29; occasional charcoal fragments throughout; sharp to
201.16–201.04	Continuation of above; common charcoal; sharp to
201.04–200.73	Reddish brown and grey laminated silty clay; gradual to
200.73–200.63	Mottled light grey wet clayey silt; gradual to
200.63–200.09	Light grey clayey silt; sharp to
200.09–200.06	Horizontal wood fragment (archaeology); sharp to
200.06–200.04	Light grey silt containing horizontally bedded decomposed woody fragments (from piece above); charcoal-rich; sharp to
200.04–200.01	Horizontal wood fragment (archaeology); sharp to
200.01–199.98	Very dark grey to black charcoal-rich stiff clay; gradual to
199.98–199.78	Mottled dark grey and light grey stiff clay; contact obscured
199.78–199.77	Dark grey stiff clay containing occasional fine gravel
199.77–199.38	Reddish brown and grey mottled sandy gravely clay becoming increasingly sandy downwards (especially below 199.50); sharp to
199.38–	Light grey and black mottled clay containing occasional wood

199.35	fragments (1.5 cm x 1 cm in size); sharp to
199.35–199.21	Reddish brown sandy clay; gradual to
199.21–199.13	Reddish brown silty sand, fining downwards; sharp to
199.13–198.95	Reddish brown clay containing common plant remains (*Phragmites* stems) between 199.13–199.01; sharp to
198.95–198.92	Reddish brown silty sand; gradual to
198.92–198.77	Reddish brown clay
198.77–198.67	Continuation of above; gradual to
198.67–198.55	Reddish brown sandy clay becoming silty clay downwards; gradual to
198.55–198.23	Reddish brown sandy silty clay; gradual to
198.23–198.06	Mottled light grey and reddish brown silty clay; gradual to
198.06–197.98	Reddish brown silty clay; gradual to
197.98–197.77	Reddish brown silt; gradual to

Table 6: BH80 (32N 324295, 5406431)

Elevation (m a.s.l.)	**Description**
201.63–201.18	Dark brown silt containing common briquetage and charcoal, and occasional limestone fragments (trench back–fill); sharp to
201.18–200.98	Light grey and reddish brown mottled clay rich in briquetage and charcoal in the upper 7 cm; blocky briquetage at 201.16; gradual to
200.98–200.59	Reddish brown and light grey mottled silty clay rich in decomposed plant matter; sharp to
200.59–200.27	Light grey–olive grey sticky silt rich in plant (*Phragmites* stem) remains throughout; gradual to
200.27–199.69	Faintly mottled light grey sticky silt becoming dark grey downwards; occasional plant (*Phragmites*) remains throughout
199.69–199.63	Continuation of above; contains 1 cm thick horizon of decomposed plant matter
199.63–199.53	Dark brown silty clay containing common fine plant matter; occasional charcoal and sand and fine gravel-sized briquetage (≤0.3 cm); gradual to
199.53–199.37	Mottled light grey silty clay containing black organic streaks, becoming less frequent downwards; gradual to
199.37–199.08	Light grey silty clay containing occasional decomposed plant remains; sharp to
199.08–199.06	Very light grey fine sandy silty clay containing fine sand and gravel; sharp to
199.06–199.03	Dark brown to black organic fine sandy silty clay containing decomposed plant remains
199.03–199.00	Mottled olive grey stiff sandy silty clay containing fine gravel; sharp to

199.00–198.98	Dark reddish brown organic fine sandy silty clay containing occasional very fine gravel (<0.5 cm); sharp to
198.98–198.96	Olive grey and reddish brown mottled silty clay; sharp to
198.96–198.955	Continuation of 199.00–198.98; sharp to
198.955–198.73	Mottled olive grey and reddish brown fine sandy silty clay containing black organic streaks; occasional plant remains; gradual to
198.73–198.63	Reddish brown fine sandy silt containing occasional black bands and plant (*Phragmites*) remains

Table 7: BH81- L (32N 324293, 5406426)

Top 1 m of core (201.57–200.57 m a.s.l.) not retained for laboratory description

Elevation (m a.s.l.)	**Colour**	**Description**
200.57–200.45	5Y 5/2 Olive grey	Soft silt containing 5Y 4/1 dark grey vertical mottles (root channels?), becoming dark grey silt; olive grey vertical mottles below 200.49; occasional plant (*Phragmites*) remains throughout; occasional fine sand between 200.485–200.45; gradual to
200.45–200.43	5Y 7/1 Light grey	Soft silt containing 5Y 4/1 dark grey mottles; occasional fine sand and plant (*Phragmites*) remains; moat fill; sharp to
200.43–199.99	5Y 4/1 Dark grey	Soft silt; faintly mottled; occasional plant (*Phragmites*) remains; moat fill; sharp to
199.99–199.95	5Y 2.5/1 Black	Gritty sandy silt containing blocky briquetage (>2 cm) and occasional plant (*Phragmites*) remains; gradual to
199.95–199.89	5Y 2.5/1 Black	Peaty sandy silt rich in plant remains; bed of *Phragmites* stems at 199.94–199.93; briquetage pottery fragment (1 cm); sharp to **770–430 cal BCE (Beta–310885): 199.95–199.94 m a.s.l.**
199.89–199.83	2.5YR 4/6 Red	Blocky briquetage in wet sandy silt matrix (5Y 2.5/1 black); sharp to
199.83–199.81	5Y 3/1 Very dark grey	Silty sand containing occasional blocky briquetage; sharp to
199.81–199.79	5Y 4/1 Dark grey	Soft wet sandy silt containing coarse sand and occasional gravel-sized briquetage (≤0.5 cm); sharp to
199.79–199.76	2.5YR 4/6 Red	Blocky briquetage fragment in 5Y 4/2 olive grey wet silty matrix; sharp to
199.76–199.71	2.5YR 4/6 Red	Blocky briquetage fragment in coal-black soft silty matrix (very charcoal-rich); woody fragment at 199.72 (0.5 cm x 0.5 cm); sharp to
199.71–199.67	Coal-black	Soft clayey silt with faintly peaty texture (very charcoal rich?); sharp to
199.67–199.65	7.5YR 5/4 Brown	Wet crumbly block of briquetage in coal–black (very charcoal rich) silty matrix; sharp to
199.65–	Coal-	Continuation of 199.71–199.67; blocky briquetage fragment

199.60	black	present on surface of core at 199.63–199.61 (in–situ?); gradual to
199.60–199.57	5Y 2.5/1 Black	Charcoal-rich silt; layer of wood (archaeology) at 199.59–199.585
199.57–199.55	5Y 2.5/1 Black; 2.5Y 4/1 Dark grey	Organic silty clay; faintly horizontally banded; sharp to
199.55–199.50	2.5Y 4/1 Dark grey	Silty clay containing occasional black flecks (charcoal?); briquetage fragment (1 cm) towards surface of core at 199.54–199.53 (*in-situ*?); gradual to
199.50–199.48	2.5Y 4/1 Dark grey	Coarse sandy clay; gradual to
199.48–199.45	2.5Y 4/1 Dark grey; 2.5Y 2.5/1 Black	Faintly horizontally banded silty clay containing occasional coarse sand; gradual to
199.45–199.40	2.5Y 4/1 Dark grey; 2.5Y 2.5/1 Black	Faintly horizontally banded coarse sandy clayey silt; sharp to
199.40–199.31	2.5Y 5/4 Light olive brown; 2.5Y 5/1 Grey	Mottled sandy silt; gradual to
199.31–199.18	7.5YR 4/3 Brown	Sandy silt; sharp to
199.18–199.04	2.5Y 5/2 Greyish brown	Faintly mottled silty sand containing occasional hard woody remains (twigs/stems) at 199.13 and 199.10 (0.5 cm x 0.2 cm); gradual to
199.04–198.77	7.5YR 4/2 Brown; 2.5Y 5/1	Faintly mottled clay containing occasional black organic flecks; occasional 7.5YR 5/4 strong brown staining (Fe staining); gradual to

	Grey	
198.77–198.57	7.5YR 4/3 Brown	Sandy silty clay, becoming sandy silt downwards; common black organic flecks throughout

Table 8: BH82 (32N 324294, 5406431)

Elevation (m a.s.l.)	Description
201.54–201.23	Hard dry dark brown silty clay (pedogenically altered alluvium) containing common sand and gravel-sized briquetage and occasional charcoal; modern roots; sharp to
201.23–201.11	Faintly mottled reddish brown clay containing occasional decomposed plant matter; sharp to
201.11–201.10	Continuation of 201.54–201.23; sharp to
201.10–200.88	Continuation of 201.23–201.11; sharp to
200.88–200.78	Dry silty clay rich in gravel-sized and blocky briquetage (≤2.5 cm) (briquetage not *in–situ*); sharp to
200.78–200.58	Mottled reddish brown and light grey stiff clay containing occasional black organic bands; bands of decomposed plant matter at 200.77 and 200.73–200.68; sharp to
200.58–200.54	Light grey silty clay containing common plant (*Phragmites*) remains
200.54–200.49	Mottled light olive grey and dark grey fine sandy silt containing oyster shell fragments and common plant remains; sharp to
200.49–200.30	Mottled dark grey and light grey soft silt containing occasional fine decomposed plant matter and small shell fragments; sharp to
200.30–199.84	Dark grey clayey silt; sharp to
199.84–199.79	Horizontally bedded black organic sandy gravely silt (0.3–2 cm) containing common fine decomposed plant matter; woody stem (2.5 cm long) at 199.80; sharp to
199.79–199.76	Light grey silty clay lens in black organic silt; occasional decomposed plant remains; sharp to
199.76–199.67	Black silty clay rich in very fine charcoal; briquetage fragment (2 cm x 0.5 cm) at 199.74–199.72; transition from silty clay to clay at 199.72; sharp to
199.67–199.50	Mottled black and dark grey clay containing black flecks (possibly charcoal); gradual to
199.50–199.41	Mottled light olive grey, black and reddish brown clay containing coarse sand/fine gravel and occasional decomposed plant remains; gradual to
199.41–199.14	Mottled light olive grey and reddish brown sandy silty clay containing coarse sand/fine gravel and occasional black (organic) flecks; gradual to
199.14–198.94	Faintly mottled reddish brown and light olive grey sandy silty clay containing occasional black (organic) flecks and common fine plant matter; gradual to
198.94–198.91	Reddish brown clay-rich sand containing occasional plant remains; gradual to
198.91–198.85	Reddish brown sandy clay containing sparse fine gravel and occasional black (organic) flecks; gradual to
198.85–198.79	Mottled olive grey and reddish brown sandy clay; gradual to

198.79–198.74	Reddish brown silty sand containing vertical root; gradual to
198.74–198.70	Reddish brown stiff sandy clay; gradual to
198.70–198.67	Reddish brown silty sand containing occasional plant remains; gradual to
198.67–198.54	Reddish brown stiff sandy clay containing black (organic) flecks

Table 9: BH87 (32N 324182, 5406432)

Elevation (m a.s.l.)	**Description**
201.97–201.87	Dark brown silt containing modern roots and sand-sized briquetage (pedogenically altered alluvium); sharp to
201.87–201.41	Mottled reddish brown clay containing common gravel-sized briquetage (up to 1 cm) and charcoal fragments; modern roots down to 201.62; gradual to
201.41–201.31	Faintly mottled reddish brown silt containing common decomposed plant remains; gradual to
201.31–201.04	Mottled reddish brown and grey silt containing occasional decomposed plant remains; gradual to
201.04–200.97	Grey silt containing common plant matter; core expanded
200.97–200.90	Grey silt containing common plant (*Phragmites*) remains; layer of fine sand at 200.90 (~0.3 cm thick); sharp to
200.90–200.62	Dark grey faintly mottled organic silt containing common laminated plant remains; sharp to
200.62–200.61	Light grey silt; sharp to
200.61–200.42	Dark brownish grey organic silt rich in woody plant remains; occasional mollusc shells; sharp to
200.42–200.41	Dark grey silt; sharp to
200.41–199.90	Grey silt containing common plant remains and occasional mollusc shells; large bone fragment (4 cm x 1 cm) at 200.32–200.31; woody fragment at 204; sharp to
199.90–199.60	Mottled grey and black silty clay containing common clay pellets and black charcoal-rich flecks/streaks; occasional fine gravel-sized briquetage (≤0.5 cm), fine gravel and plant remains; sharp to
199.60–198.97	Reddish brown to grey silty clay becoming greyer towards base; common sand-sized briquetage and plant remains; occasional shell fragments and gravel; occasional gravel-sized briquetage and charcoal throughout, most frequent between 199.60–199.47 becoming sparser downwards; large bone fragment (3 cm x 1.5 cm) at 199.02
198.97–198.52	Dark grey silty clay containing sparse plant remains and shell fragments; sparse sand-sized briquetage and charcoal down to 198.58; sharp to
198.52–198.48	Light grey silt; sharp to
198.48–197.97	Dark grey sandy gravely silt containing common plant remains and fine gravel; charcoal fragments at 198.33; blocky briquetage (3 cm x 3 cm) at 198.06–198.03 (part of briquette) surrounded by smaller blocky and gravel-sized briquetage – typologically dated to Hallstatt D1

Table 10: BH88-L (32N 324178, 5406417)

Elevation (m a.s.l.)	Colour	Description
201.99–201.84	7.5YR 2.5/2 Very dark brown	Silty clay (pedogenically altered alluvium) containing modern roots and sparse sand and fine gravel-sized briquetage (≤ 0.2 cm); sharp to
201.84–201.40	7.5YR 4/3 Brown	Stiff clay containing sand and gravel-sized briquetage (≤0.8 cm); modern roots down to 201.41; rich in blocky briquetage between 201.59–201.51 and 201.48–201.43; small charcoal fragment at 201.56 (0.2 cm); sharp to
201.40–201.35	7.5YR 4/3 Brown	Faintly mottled clay containing occasional sand and decomposed plant remains; sharp to
201.35–201.34	7.5YR 2.5/1 Black	Peat; sharp to
201.34–201.16	7.5YR 4/3 Brown	Faintly mottled silty clay with peaty inclusions (not *in–situ*) at 201.31, 201.30–201.27 and 201.25; sparse sand-sized briquetage throughout; occasional fine plant matter below 201.22; gradual to
201.16–201.01	7.5YR 4/2 Brown	Faintly mottled clayey silt containing common decomposed and fine plant matter; very sparse fine charcoal at 201.13 and 201.04; woody remains at 201.05; gradual to
201.01–200.98	7.5YR 4/1 Dark grey	Silt rich in plant remains; occasional fine shell fragments
200.98–200.56	7.5YR 4/1 Dark grey; 7.5YR 6/1 Grey	Mottled organic silt; visible sand beds at 200.92–200.91, 200.667–200.665, 200.657–200.655, 200.647–200.646, 200.631–200.63, 200.606–200.604 and 200.591–200.589; common plant remains (including *Phragmites*) throughout; plant-rich beds at 200.94, 200.92–200.91, 200.586–200.584 and 200.576–200.571; sharp to
200.56–200.49	7.5YR 4/1 Dark grey	Organic fine sandy silt rich in fine plant matter and *Phragmites*; woody fragment at 200.55; gradual to
200.49–200.44	7.5YR 3/1 Very dark grey	Organic silty clay containing occasional fine plant remains; sparse coarse sand; sparse sand-sized briquetage; sharp to
200.44–200.39	7.5YR 3/1 Very dark grey	Organic silty clay containing common sand and gravel-sized briquetage; occasional fine plant matter and coarse sand; sharp to
200.39–200.29	7.5YR 4/1 Dark grey	Organic silty clay containing occasional fine plant matter; sparse fine sand; sparse sand-sized briquetage down to 200.29, becoming common below this; gradual to

200.29–199.99	7.5YR 4/1 Dark grey	Silty clay containing common black flecks and plant matter; occasional sand and fine gravel-sized briquetage (≤ 0.3 cm); very sparse coarse sand; becomes fine sandy silty clay below 200.06
199.99–199.45	7.5YR 4/1 Dark grey	Silty clay rich in fine plant matter; common sand-sized briquetage; occasional fine gravel/coarse sand; sharp to
199.45–199.42	7.5YR 4/1 Dark grey	Wet sandy silty clay containing well preserved *Phragmites* stem; sharp to
199.42–199.04	7.5YR 4/1 Dark grey	Silty clay rich in fine plant matter; occasional fine gravel/coarse sand; gradual to
199.04–198.99	7.5YR 3/1 Very dark grey	Silty clay containing common charcoal flecks (≤0.1 cm), sparse sand-sized briquetage and occasional fine plant remains; charcoal fragment at 199.03 (0.5 cm x 0.2 cm)
198.99–198.82	7.5YR 3/1 Very dark grey	Sandy silt containing occasional fine plant matter and sparse coarse sand; very sparse sand-sized briquetage between 198.95–198.92; charcoal fragments at 198.95, 198.93 and 198.90; gradual to
198.82–198.70	5YR 3/1 Very dark grey	Sandy silt containing occasional plant (*Phragmites*) remains and charcoal fragments (≤ 5 mm); sand-sized briquetage fragment at 198.78; gradual to
198.70–198.64	5YR 3/1 Very dark grey	Silt; gradual to
198.64–198.60	5YR 3/1 Very dark grey	Silty sand containing common very fine charcoal flecks (≤1 mm); Gley 5/1 greenish grey horizontal silt lens at 198.635–198.63 (0.5 cm x 2 cm); gradual to
198.60–198.06	5YR 3/1 Very dark grey	Silt containing common plant remains; occasional coarse sand; sparse fine gravel and fine shell fragments; charcoal fragment at 198.34 (0.5 cm x 0.2 cm); sub-angular gravel clast (0.5 cm) and clast of dried clay (unfired briquetage?) (0.5 cm) at 198.11; gradual to
198.06–197.99	7.5YR 2.5/1 Black	Sandy silt containing common coarse sand and fine plant matter; diagonally orientated angular shard of bone at 198.05–198.03 (3 cm x 1 cm); charcoal fragment at 198 (0.5 cm x 0.2 cm); sand-rich between 198.03–198.01, becoming sandy silty gravel at this depth
197.99–197.78	2.5Y 3/1 Very dark grey	Sandy silt containing common plant matter, including wood at 197.89–197.88 (up to 2 cm x 1 cm); occasional coarse sand/fine gravel; very sparse fine shell fragments; charcoal fragment at 197.83 (0.5 cm x 0.2 cm); sharp to **2570–2310 cal BCE (Beta–310887): 197.80–197.78 m a.s.l.**
197.78–197.58	2.5Y 4/1 Dark grey	Sandy gravel (angular and sub-angular) containing occasional fine shell fragments; sharp to
197.58–197.39	2.5Y 4/1 Dark grey	Silty gravely sand containing common woody remains (up to 1 cm x 0.5 cm) and common Mollusca; sharp to

197.39–197.27	2.5Y 3/1 Very dark grey	Sandy silt containing common woody remains (up to 4 cm x 2 cm) and occasional fine shell fragments; sharp to **1680–1520 cal BCE (Beta–310888): 197.39–197.35 m a.s.l.**
197.27–197.15	2.5Y 4/1 Dark grey	Silty gravely sand containing occasional fine shell fragments; sharp to **9660–9290 cal BCE (Beta–310889): 197.15–197.13 m a.s.l.**
197.15–196.99	2.5Y 4/3 Olive brown	Silty sand containing common plant remains and Mollusca (whole and broken shells)

Table 11: BH97 (32N 324245, 5406386)

Elevation (m a.s.l.)	**Description**
202.39–202.00	Dark brown dry crumbly silt containing modern roots (pedogenically altered alluvium); blocky briquetage fragment between 202.22–202.15; contact obscured
202.00–201.59	Stiff reddish brown clay containing common briquetage and charcoal; blocky briquetage at 202.00–201.97 and 201.90–201.88; gradual to
201.59–201.50	Grey clay containing common sand-sized briquetage; occasional shell fragments; sharp to
201.50–201.39	Reddish brown sandy silt rich in sand and gravel-sized briquetage
201.39–200.83	Brownish grey sandy gravely silt rich in briquetage and charcoal; blocky briquetage at 201.39–201.29 and 201.15–201.10; blocky briquetage at 201.10–201.04 and 200.91–200.83; contact obscured
200.83–200.60	Reddish brown silty gravely sand containing common charcoal and sand-sized briquetage; sharp to
200.60–200.39	Dark greyish brown wet sandy gravely silt rich in charcoal; occasional sand-sized briquetage
200.39–199.39	Wet slurry of briquetage and charcoal in dark greyish brown sandy gravely silt; blocky briquetage throughout together with sand and gravel-sized briquetage; charcoal-rich layers at 199.99–199.89 and 199.74–199.64
199.39–199.29	Blocky briquetage in wet brown sandy silty matrix; gradual to
199.29–198.65	Wet brown sandy gravely silt rich in blocky briquetage and charcoal; sharp to
198.65–198.55	Dark greyish black sandy gravely silt rich in gravel-sized briquetage and woody remains; sharp to
198.55–198.39	Wet dark brown sandy gravely silt rich in blocky briquetage and charcoal
198.39–198.18	Reddish orange blocky briquetage; sharp to
198.18–198.06	Dark greyish brown wet sandy gravely silt containing common sand and gravel-sized briquetage; blocky briquetage between 198.15–198.11, becoming gravel-sized below this; sharp to
198.06–198.05	Dark greyish brown organic sandy silt rich in decomposed plant remains (peaty); sharp to
198.05–197.92	Organic light brownish grey fine sandy silty clay containing occasional decomposed plant remains; Fe nodules and olive-grey silty inclusions below 198.04; sharp to

197.92–197.75	Light brownish grey sandy silt containing common fine plant remains; gradual to
197.75–197.70	Reddish brown sandy silt containing common Fe nodules; gradual to
197.70–197.39	Reddish orange gravely silty sand containing common fine gravel and occasional decomposed plant remains

Table 12a: BH99 (field description) (32N 324234, 5406361)

Top 4 metres of core (202.66–198.66 m a.s.l.) described in the field. Bottom 1 m of core (198.66–197.66 m a.s.l.) retained for laboratory description and radiocarbon dating (Table 12b).

Elevation (m a.s.l.)	**Description**
202.66–202.39	Brown crumbly silty clay containing modern roots (pedogenically altered alluvium); common sand and gravel-sized briquetage below 202.55; gradual to
202.39–202.02	Brownish grey stiff clay containing modern roots (pedogenically altered alluvium); common sand and gravel-sized briquetage; blocky briquetage fragment at 202.06–202.02; sharp to
202.02–201.99	Dark greyish brown silt containing common charcoal and sand and gravel-sized briquetage; sharp to
201.99–201.77	Reddish orange compact blocky briquetage and occasional charcoal; sharp to
201.77–201.73	Light brownish yellow clay containing sand-sized briquetage; sharp to
201.73–201.69	Continuation of 201.99–201.77; sharp to
201.69–201.64	Brown crumbly silt rich in sand and gravel-sized briquetage and charcoal; sharp to
201.64–201.15	Reddish orange compact blocky briquetage (crumbling) and large charcoal fragments (branches) 3 cm x 0.2 cm in size; sharp to
201.15–201.09	Yellowish brown silt containing common charcoal and sand-sized briquetage; sharp to
201.09–201.06	Continuation of 201.64–201.15; sharp to
201.06–201.04	Grey silt containing common charcoal; sharp to
201.04–200.84	Dark brownish black and light brown mottled sandy gravely silt rich in charcoal and common sand and gravel-sized briquetage; sharp to
200.84–200.66	Blocky briquetage in brownish grey sandy gravely silt matrix
200.66–199.82	Wet blocky briquetage in brown silty matrix; bone fragment at 200.62; occasional charcoal; briquetage less frequent below 200.30; sharp to
199.82–199.66	Very dark greyish black organic sandy silt rich in sand and gravel-sized briquetage; increasingly organic towards base
199.66–199.45	Compact briquetage; sharp to
199.45–198.95	Very dark greyish black organic sandy silt rich in charcoal; common sand and gravel-sized briquetage; sharp to
198.95–198.85	Blocky briquetage; sharp to

198.85–198.66	Continuation of 199.66–198.45; contact obscured

Table 12b: BH99-L (laboratory description) (32N 324234, 5406361)

Elevation (m a.s.l.)	**Colour**	**Description**
198.66–198.15	5YR4/4 Reddish brown	Clast-supported briquetage in a gritty earthy clayey sand matrix; massive (structureless), compact; well-marked transition to
198.15–197.95	Very dark grey to black	Matrix-supported briquetage in a gritty sandy matrix; massive (structureless), less compact than overlying unit; abundant charcoal; well-marked/sharp contact with
197.95–197.87	Dark grey	Granule-rich medium to coarse sand; massive (structureless); scattered detrital plant remains; very scattered fragments of mollusc shell; very sharp contact **1940–1700 cal BCE (Beta–310890): 197.93–197.89 m a.s.l.**
197.87–197.66	2.5Y4/3 Olive brown	Sandy clay packed with small (granule to fine gravel) clasts comprising a wide variety of rock types, including well-rolled, sub-angular and angular clasts of clay and mudstone, and angular to well-rolled clasts of a harder rock types; massive (structureless), compact

Table 13: BH100 (32N 324235, 5406385)

Elevation (m a.s.l.)	**Description**
202.66–202.17	Dark brown silty clay containing modern roots and common gravel-sized briquetage (pedogenically altered alluvium); sharp to
202.17–201.80	Sandstone and limestone rubble (hard core); sharp to
201.80–201.77	Blocky briquetage; sharp to
201.77–201.75	Yellow fine sand; sharp to
201.75–201.66	Mottled yellowish brown sandy clay rich in sand and gravel-sized briquetage; blocky briquetage at base
201.66–201.48	Reddish brown and grey mottled silty gravely clay containing occasional blocky briquetage and charcoal; occasional fine gravel; freshwater mollusc shell at 201.53; sharp to
201.48–201.42	Reddish brown silty clay; contact obscured
201.42–201.19	Reddish brown–grey silty clay containing occasional sand and gravel-sized briquetage and charcoal; sharp to
201.19–201.18	Reddish brown–grey sand; sharp to
201.18–201.03	Reddish brown–light grey mottled silt rich in blocky and gravel-sized briquetage; occasional charcoal; gradual to
201.03–200.66	Reddish brown sandy gravely silt rich in charcoal and sand and gravel-sized briquetage; blocky briquetage (2 cm) at base; common fine plant

	remains
200.66–199.66	Wet slurry of blocky briquetage and charcoal in sandy silty matrix
199.66–199.34	Dense unit of compact reddish orange briquetage; sharp to
199.34–199.04	Dark grey organic sandy gravely silt containing sparse plant matter and woody remains; blocky briquetage at 199.07–199.04; blocky briquetage also pushed into surface at 199.34–199.29 (not *in–situ*); occasional charcoal from 199.34–199.12; gravel-sized briquetage between 199.22–199.12; sharp to
199.04–199.02	Light grey sand; sharp to
199.02–198.66	Continuation of 199.34–199.04; blocky briquetage at 198.99 and 198.92–198.88
198.66–198.05	Dark grey sandy silt rich in plant remains; sparse charcoal between 198.66–198.23; sharp to
198.05–198.02	Dark grey silty sandy gravel; sharp to
198.02–197.91	Continuation of 198.66–198.05; sharp to
197.91–197.66	Grey sandy silty gravel

Table 14: BH104 (32N 324245, 5406425)

Elevation (m a.s.l.)	Description
202.10–201.96	Brown dry stiff clay; modern roots; occasional sand-sized briquetage; sharp to
201.96–201.66	Blocky briquetage; contact obscured (probably sharp)
201.66–201.45	Greenish grey mottled stiff clay; occasional sand-sized briquetage and fine plant matter; sharp to
201.45–201.38	Grey clay; rich in crumbling sand and gravel-sized and blocky briquetage; common limestone nodules; limestone clast at 201.40–201.38; sharp to
201.38–201.26	Greenish grey silty clay; common sand and gravel-sized briquetage and blocky briquetage; occasional charcoal; modern roots; gradual to
201.26–201.10	Dark grey silt; rich in plant (*Phragmites*) remains
201.10–200.80	Brownish grey silt rich in laminated plant (*Phragmites*) remains; gradual to
200.80–200.50	Dark grey silty clay; common fine plant remains; gradual to
200.50–200.35	Dark grey dry crumbly silty clay; occasional sand and gravel-sized briquetage; common fine plant remains and roots; shell beds and peaty inclusions; sharp to
200.35–200.10	Blocky briquetage; occasional charcoal and ash
200.10–199.87	Very wet slurry of brown sandy silt rich in sand and coarse gravel-sized briquetage (up to 3 cm); loose/unconsolidated; gradual to
199.87–199.10	Wet slurry of compact blocky briquetage in brown sandy silt; occasional charcoal; large wood fragments at 199.65–199.43; common fine plant

	matter
199.10–198.89	Blocky briquetage in wet brown sandy silty matrix; sharp to
198.89–198.54	Dark greyish brown sandy silt; rich in sand and coarse gravel-sized briquetage; large horizontal charcoal fragment at 198.85 (5 cm x 1 cm); sharp to
198.54–198.53	Blocky briquetage in wet brown sandy silty matrix
198.53–198.38	Dark greyish brown silty fine sandy gravel; rich in sand-sized briquetage; horizontal bone shard at 198.47 (4 cm x 3 cm); blocky briquetage at 198.38; sharp to
198.38–198.29	Wet brown silty sandy gravel; horizontal wood fragment at 198.38 (6 cm x 1 cm); common fine and coarse gravel-sized briquetage; common small charcoal; sharp to
198.29–198.10	Grey sandy silty clay; occasional wood at 198.28; occasional sand and gravel-sized briquetage throughout; blocky briquetage fragment in base
198.10–197.98	Dark grey fine sandy gravely silty clay; common whole and broken Mollusca; occasional sand-sized briquetage; common fine plant remains; gradual to
197.98–197.91	Dark grey silty clay; common *Phragmites* remains; occasional broken shell; sharp to
197.91–197.86	Alternating horizons of yellow sand and dark grey–olive grey sandy silty clay; gradual to
197.86–197.60	Olive greyish brown sandy silty clay; yellow sand inclusions; occasional decomposed plant remains (peaty) and broken shell; gradual to
197.60–197.48	Banded dark grey and olive brown sandy silty clay; yellow sand horizons; common laminated plant (*Phragmites*) remains; occasional whole and broken Mollusca; sharp to
197.48–197.478	Yellow sand; sharp to
197.478–197.47	Yellowish brown sandy silty clay; sharp to
197.47–197.46	Yellow sand; sharp to
197.46–197.33	Olive grey sandy silt; common Mollusca and *Phragmites*; sharp to
197.33–197.30	Dark olive grey silty clay; sharp to
197.30–197.24	Dark greyish brown sandy silt; common Mollusca; sharp to
197.24–197.241	Orange sand; sharp to
197.241–197.22	Dark grey silty sand; sharp to
197.22–197.218	Yellow sand containing Mollusca; sharp to
197.218–197.20	Brownish grey silty clay; sharp to
197.20–197.10	Wet grey sandy gravel

Table 15: BH105 (32N 324246, 5406446)

Elevation (m a.s.l)	Description
201.97–201.76	Dark brown stiff dry clay; modern roots; common sand and gravel-sized briquetage; occasional small limestone clasts at 201.89–201.81; sharp to
201.76–201.28	Blocky briquetage in dark brown dry stiff clay matrix; modern roots; sharp to
201.28–201.19	Brownish grey silty clay; small charcoal and sand-sized briquetage; faintly mottled; sharp to
201.19–201.16	Continuation of 201.76–201.28; sharp to
201.16–201.01	Reddish brown silty clay; fine plant remains; sharp to
201.01–200.89	Blue–grey silt rich in *Phragmites*; common Mollusca; sharp to
200.89–200.24	Dark grey silt; mottled between 200.89–200.83 and 200.70–200.65; sharp to
200.24–200.14	Blocky briquetage in dark brownish black silty sandy gravely matrix; gradual to
200.14–199.97	Wet dark reddish brownish black silty sandy gravel; rich in charcoal and sand and gravel-sized briquetage; blocky briquetage at base
199.97–199.48	Coarse gravel-sized briquetage and charcoal; loose/unconsolidated; briquetage increasing in size towards base; sharp to
199.48–198.97	Wet slurry of blocky and gravel-sized briquetage and charcoal in greyish brown sandy silty matrix
198.97–198.81	Compacted reddish brown blocky briquetage; occasional charcoal; gradual to
198.81–198.68	Compacted dark reddish brown sandy silt; blocky briquetage; occasional plant remains and charcoal; sharp to
198.68–198.61	Compacted single piece of briquetage; sharp to
198.61–198.33	Compacted dark greyish brown sandy silt; common broken shell; common gravel-sized and blocky briquetage; sharp to
198.33–198.20	Compacted blocky briquetage (2 large pieces); charcoal; sharp to
198.20–197.97	Compacted dark grey silty sand; common broken shell; occasional sand and gravel-sized briquetage; occasional charcoal (up to 1 cm x 0.2 cm); occasional gravel towards base
197.97–197.74	Light grey silty sand; contact obscured
197.74–197.45	Dark grey silty sand; gradual to
197.45–197.13	Very dark greyish black silty sand; sharp to
197.13–196.97	Reddish brown sandy and gravel; gravel increasing in size to base